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THE

PRINCIPLES OF PHYSIOLOGY

APPLIED TO THE

PRESERVATION OF HEALTH,

AND TO THE IMPROVEMENT OF

PHYSICAL AND MENTAL EDUCATION,

BY

ANDREW COMBE, M.D.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS OF EDINBURGH; PHYSICIAN EXTRAORDINARY
IN SCOTLAND TO THE QUEEN; CONSULTING PHYSICIAN TO THE KING AND
QUEEN OF THE BELGIANS; AND CORRESPONDING MEMBER
OF THE IMPERIAL AND ROYAL SOCIETY OF
PHYSICIANS OF VIENNA.

FOURTEENTH EDITION,
REVISED AND ENLARGED.

EDITED BY

JAMES COXE, M.D.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS OF EDINBURGH.

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1852.

165. e. 18.

“Nor is it left arbitrary, at the will and pleasure of every man, to do as he list; after the dictates of a depraved humour and extravagant phancy, to live at what rate he pleaseth: but every one is bound to observe the Injunctions and Law of Nature, upon the penalty of forfeiting their health, strength, and liberty—the true and long enjoyment of themselves.”—MAYNWAYRINGE.

TO

HIS MAJESTY

LEOPOLD THE FIRST,

KING OF THE BELGIANS.

SIRE,

IN consenting to ascend the Throne, to which you were called by the fervent prayer of the Belgian people, your Majesty was graciously pleased to declare, that, having from early life been placed in many difficult and trying situations, you had learned to value power only as a means of advancing the solid and lasting happiness of your fellow-creatures. How nobly your Majesty has redeemed the pledge implied in this generous assurance, the tranquillity, security, and increasing prosperity of your Majesty's adopted country proclaim in language which it requires not the aid of individual testimony to confirm; and I venture to refer to it only because your Majesty's gracious permission to dedicate to you a work having for its aim the prevention and alleviation of human suffering is but another proof of the sincerity of the feeling by which it was dictated, and of the deep interest which your Majesty takes in every thing connected with the welfare and improvement of mankind.

As every amelioration of the physical condition of the people conduces not less to their advancement in intelligence and good conduct than to their bodily comfort, I am inclined to hope that, even in a moral point of view, some good may be effected by the present exposition of the more important laws of the animal economy, and of the numerous practical advantages to be expected from their regular and adequate fulfilment.

While thus laying my little work before your Majesty as a sincere though humble tribute of respect and admiration, may I be farther permitted to express my profound gratitude for the condescending goodness with which you have been pleased to receive my imperfect services, as well as for the professional confidence with which your Majesty continues to honour me.

That your Majesty may long be spared, in health and happiness, to watch over the interests of the Belgian nation, is the sincere and earnest wish of,

SIRE,

Your Majesty's most grateful

and devoted Servant,

ANDREW COMBE.

EDINBURGH, *November* 1, 1838.

THE AUTHOR'S PREFACE

TO THE

TWELFTH EDITION.

THE first edition of the present work made its appearance in the spring of 1834. At that time, Physiology had attracted so little public attention, and so many popular prejudices were arrayed against its becoming a subject of general instruction, that, doubtful of my own ability to excite that interest in its favour which I was conscious it deserved, I felt some hesitation in venturing upon an edition of even 750 copies, as I expected that some years at least would elapse before another would be required. To my equal surprise and gratification, however, the public appreciation of, and desire for, physiological information have far exceeded my most sanguine expectations. Already, in Great Britain and Ireland, eleven editions, consisting together of 16,000 copies, have been exhausted; and in the United States of America, where foreigners enjoy no copyright, upwards of 30,000 copies were sold within the first six years. On the Continent also, the work has been favourably received—a German translation having appeared at Leipsic in 1837, and a Danish one subsequently at Copenhagen. These facts shew unequivocally, that the practical value of physiological knowledge is every day becoming better understood among the intelligent classes of society, and that the present attempt to communicate it, in a plain and unambitious style, has not been unsuccessful.

At the time when the first edition appeared, the proposition that physiology should constitute a part of general education, was generally received with ridicule or doubt, and by very many with absolute disgust. Of late, on the contrary, opinion has been almost unanimous in its favour, and allusions to the doctrines and usefulness of physiology meet us on every side. In accordance with this, its laws are now frequently referred to by men of philosophic minds, as the standards by which every proposition for the physical, social, or moral improvement of man should be tested. This happy change is likely to be progressive, because it has arisen from the gradual diffusion of sounder ideas, and from the preference instinctively felt for useful truths, when once clearly presented to the understanding.

That progress is really making in a right direction, may further be inferred from the numerous examples every day presenting themselves, of the successful application of physiological principle to the promotion of human improvement. Among many others, I may refer to the pains taken, and the expense incurred, by Government, in the ventilation, lighting, and heating of the new Houses of Parliament, and many of the public Offices and Hospitals; to the recent official investigation into the means required for promoting health in large towns; to the attention now devoted to secure an improved construction of houses, a better supply of water, more thorough draining, and a more adequate supply of the necessaries and comforts of life, as well as a proper system of education and moral training, for the labouring poor; and lastly, to the special provision so carefully and intelligently made in the army and navy, for the health, morality, and comfort of the men. All these and many other examples afford striking proofs of the extent to which a perception of the influence of the laws of physiology now pervades the more enlightened portion of the community; and warrant the hope that a much higher degree of improvement may yet be reached by the wider diffusion and application of physiological knowledge than is at present generally expected. To effect this, however, not only parents and the teachers of the young, but the young themselves, of all ranks and both sexes, must be made familiar, at an early age, with the nature of their own organism, and *trained by example*, as well as by precept, to the practical observance of the laws by which their functions are regulated.

It is with a strong wish to contribute all in my power to this most desirable end, that I have placed this volume within the reach of every class, and especially of the many parents and teachers, both male and female, who have never enjoyed an opportunity of acquiring correct information regarding the physical and mental constitution of man, and who, with the very best intentions, and the strongest desire to discharge their duty, often fall involuntarily into error for want of it.

Even with every aid, the task of the educator is not less arduous than important; and if his success does not always correspond to the zeal, talent, and industry which he brings to its performance, the cause is to be looked for in the prevailing ignorance of the nature of man, far more than in any deficiency peculiar to the individual. Every experienced medical man must be familiar with cases where efforts which, under the guidance of physiological knowledge, would have secured the richest harvest of results, have either been expended in vain, or even been productive of direct, and sometimes permanent, injury to the pupil. To parents and teachers, then, this volume is offered, in the hope that it may afford them both aid and comfort. That it is far from sufficient to satisfy all their wants, no one is more fully aware than its author; but it may nevertheless help to guide them in a right direction, and enable them to pursue their important labours with increased credit and success. But it is right to warn them beforehand, that the benefit to be derived from the following pages will depend mainly on the spirit in which they are perused. The subjects treated of embrace so many important facts and principles of action, which are comparatively new to the general reader, that it is only by careful and frequent study that he can become sufficiently familiar with them to avail himself of the applications of which they are capable to the purposes of self-education and improvement, and to the preservation or recovery of health. To read merely as one reads a novel or a newspaper, can be productive of but little solid or permanent advantage; and therefore, while I value highly the grateful tribute implied in *endeavouring to act* (it may be, in silence) upon the principles expounded in my works, I feel indifferent to even the most eloquent and laboured eulogium, when it is not accompanied by any practical results. I am the more anxious to enforce this view, because many will, I believe, read with increased interest and advantage after their attention has been thus earnestly directed in the very outset to the practical character and aim of the work.

In further pursuit of this object, I have published two additional volumes of the same plain and practical character with that now in the hands of the reader, and, like it (to adopt the words of the German title-page), designed "especially for the use of parents, teachers, the young, and all who take an interest in their own welfare and happiness, or in that of others." In the first of these, on the subjects of *Digestion and Diet*, I have treated of the important functions of digestion and nutrition, and of the laws by which diet should be regulated, according to the age, constitution, and mode of life. In the second, *On the Management of Infancy*, I have endeavoured to explain, to parents and others, the nature and laws of the infant constitution, and to point out the superior safety and advantage which would result from taking these as the standard by which to regulate every part of Infant Management, moral as well as physical, instead of being guided, as is frequently the case, by mere random observation, or blind adherence to custom or tradition. The very favourable reception with which these works have been honoured, as evidenced in the sale of several very large editions, affords of itself a strong presumption that the want which they were designed to supply has been deeply and extensively felt, and at the same time amply rewards me for the pains I have bestowed in their preparation.

EDINBURGH, 25 RUTLAND STREET,
November 1843.

THE EDITOR'S PREFACE

TO

THIS EDITION.

It is now eight years since the publication of the last of the editions of this work which received improvement from the Author's hand, all the copies printed since 1844 being exact reproductions of the revised edition issued in that year. Down to the time of his death, however, in August 1847, he retained his habit of occasionally enlarging and amending the work; but his health and strength were never such as to enable him to render it so complete as he was desirous to make it, particularly in regard to the physiology of respiration and the nervous system, which had of late years been making rapid progress in the hands of many able scientific investigators. Shortly before his death, he expressed a desire that I should undertake the duties of Editor of this and his other works, in order that, to the best of my ability, I might place them on a level with the science of the day. In making this selection of an editor, he probably was influenced by the consideration that, from long and familiar intercourse with him, I was well acquainted with the views which guided him in the practice of his profession and in the composition of his popular writings, and heartily concurred with him in attaching deep importance to the diffusion, among the public at large, of a general knowledge of the structure and functions of the body, and the causes by which its health and efficiency are preserved or impaired. Having for many years been to me a "guide, philosopher, and friend," he may have thought that after his death I would make every effort in my power to secure the scientific accuracy, the clearness and earnestness of exposition, and the practical tendency, which he himself had uniformly aimed at, and which are generally allowed to characterise his works in a degree seldom equalled, and perhaps never surpassed, in any popular treatises on science. With the desire thus expressed by my lamented uncle, I felt it impossible to refuse compliance, however distrustful of my ability to perform with success the duties imposed on me. The first fruits of my editorial labours appeared in 1849, when a new edition of his Treatise on Digestion and Diet was published; and the favour with which that edition has been received by the medical profession and the public, encourages me to hope that the present amended and enlarged edition of another of his works will be found not unworthy of approbation.

The Author's own additions will, I doubt not, be as acceptable as any of his former productions; and, whatever imperfections may appear in those parts for which I am responsible, this, at least, may be affirmed with truth—that no pains have been spared to justify his selection of an editor, and to sustain the high reputation which his work has hitherto enjoyed. The volume has undergone, throughout, a severe and searching revisal, and the additions are numerous and sometimes extensive. Chapter III., in which the religious objections to the study of physiology are considered, is almost entirely from the pen of the Author himself; to whom various important additions scattered through the work are likewise attributable. The principal additions and alterations made by me occur in Chapters IV. and V., On the Structure and Functions of the Skin; Chapters X. and XI., On the Nature and Laws of Respiration; and Chapter XII., On the Nervous System: the last, indeed, has been so much enlarged, that the new portion of it considerably exceeds the old. Numerous other additions have been made by me in all parts of the volume; but as my object has been to amplify statements already made, to correct such as have been shewn by recent discoveries to be erroneous, and to illustrate and enforce by new examples the rules laid down by the Author for the preservation of health, they in no way change the former character of the work; and the present volume is therefore to be regarded as in all essential respects the work of Dr Combe. Many of the new passages will sufficiently appear to be mine, from their reference to dates or discoveries posterior to the Author's death. The principal of such as carry no evident sign of their origin, are:—those on Muscular motion, p. 88–91; Nutrition of the muscles, p. 94, 95; Waste of the tissues, p. 99; Amount and quality of exercise, p. 102–3, &c.; Muscular and nervous energy, p. 113; Capacity of the body for labour, p. 115–16; Composition and structure of the bones, p. 131, 133; Crooked spine, p. 135; Structure of the joints, p. 138; Composition of the blood, p. 140–1; Rapidity and force of the circulation, p. 150–2; Hereditary transmission of qualities, p. 296; Nature of the nervous force, p. 304. I have thought it better to point out the chief additions here, than to indicate every new passage at the place where it is introduced; for, as my sentences are frequently interwoven with the Author's, any attempt of this kind must have been but partial, and the reader's attention would have been often and needlessly distracted. In order to preserve, however, as far as possible, a marked distinction between the Author's dicta and my own, I have carefully abstained from writing in the first person singular.

It may be proper to add, that, down to the time of his death, the Author had the satisfaction of finding that the circulation of his works continued steadily to extend. Since then, several new impressions of the present treatise have been called for; and altogether, 33,000 copies have now been sold in the United Kingdom. It is probable that, in America, the circulation of the editions printed there does not fall short of 100,000 copies.

J. C.

EDINBURGH, *January* 13, 1852.

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PHYSIOLOGY

APPLIED TO

HEALTH AND EDUCATION.

CHAPTER I.

NATURE AND USES OF PHYSIOLOGY.

PHYSIOLOGY (from Φυσις, *nature*, and λογος, *discourse*) signifies literally a discourse about natural powers, but, as now used, it applies exclusively to the doctrine of the uses or functions of the different parts of beings endowed with the principle of life. Applied to the vegetable kingdom, it is called *Vegetable* Physiology; to the lower animals, *Comparative* Physiology; and to man, *Human* Physiology.

Physiology, or the history of the functions which characterize *living* beings, is a subject of deep interest; and Human Physiology, or that which is about to engage our attention, is as important in its practical consequences as it is attractive to rational curiosity. In its widest sense it comprehends an exposition of the functions of the various organs of which the human frame is composed; of the mechanism by which those functions are executed; of the relations of the organs to each other; of the means of improving their development and action; of the purposes to which they ought severally to be directed; and of the manner in which exercise should be conducted, so as to secure for the organ the best health, and for the function the highest efficiency.

On taking a general survey of the plan on which the human body is constructed, and of the uses subserved by its component parts, it becomes evident that the nervous system surpasses in importance, and is meant to preside over, all the other parts of the organism. It is by means of its great central organ, the brain, and in proportion to its development and perfection, that the various processes of sensation, perception, thought, and volition take place; and as, in this view, the body may justly be said to be the instrument of the mind, so all its component parts are placed more or less directly under the influence and control of the brain, as the more immediate organ of the mental powers. Throughout the whole animal kingdom, indeed, the same subordination of the organism at large to the nervous system may be traced, with distinctness proportioned to the intelligence of the animal, till we descend so low in the scale of being, that all traces of distinct consciousness and of nervous structure disappear together, and life becomes almost wholly vegetative.

The nervous system, then, (comprehending the brain, spinal cord, and nerves,) holds the first rank in the animal organism, because it is through it that we feel, know, think, will, and decide. Of itself, however, it could not fulfil its own behests. To become efficient, it must be placed in connection with an apparatus fitted to receive impressions from, and to act upon, external objects. The former of these purposes is fulfilled by the organs of sense, on which the nerves are ramified; the latter by what may be called the executive—namely, the trunk and limbs of the body,—which comprise, 1st, nerves to convey impressions to and mandates from the nervous centres; 2dly, bones to give stability and support; 3dly, joints to admit of motion; and, lastly, muscles and tendons to perform the mandates which the nervous centres send forth.

In addition to these organs there are others serving for the reception and digestion of food, the circulation of the blood made from it, the nourishment of the body, and the excretion of waste matter from the system. But none of these functions is altogether peculiar to animal life. All are found, in a modified degree, likewise in vegetables; and hence they are often called *vegetative functions*, to distinguish them from those peculiar to the animal kingdom. They are necessary, only because waste is an invariable accompaniment of action, and without such a provision to repair the loss of organic substance and admit of growth, life itself would speedily become extinct. Accordingly, the skin, the lungs, the liver, the kidneys, and the bowels, all form channels for the *excretion* or *throwing-out* of waste matter; while the stomach and digestive organs are expressly destined for the preparation of fresh materials from the food. And all that is still wanted in order to complete the living system, is the provision of some means by which the waste matter may be carried from all parts of the body to the excreting organs, and the new supplies be fitly distributed from the organs of digestion. These purposes are effected chiefly by the organs of circulation—namely, the heart and blood-vessels—and by the current of blood with which, by their means, every part of the body is supplied. Another class of vessels, called the lymphatics, also perform an important part in these operations.

Keeping in view this general exposition of the principles on which the human organism is constructed, and recollecting that the brain and nerves constitute the special apparatus by means of which all impressions reach the mind and all our mental operations are carried on, it is evident that a complete system of physiology will embrace an explanation not only of all the corporeal functions, but also of the nature, and laws of action, of the various appetites, propensities, and moral and intellectual faculties, with which man is endowed. A correct physiology thus constitutes the true basis on which ought to rest all plans having for their object the physical and mental health, and the social and moral improvement of man. In other words, *physiology ought to constitute the basis of all educational plans*; for, so long as life endures, the intellectual and moral powers act only through the medium and much under the influence of the organism, and no method which can be devised for their cultivation can possibly fulfil its aim, unless it be in harmony with the laws of that organism. A knowledge of the principles of physiology is, therefore, scarcely less essential to the divine, the moralist, the legislator, the teacher, and the parent, than to the physician himself. In the treatment of disease its aid is indeed invaluable; but there is scarcely any situation in life, in which an acquaintance with its doctrines may not prove at once a protection against serious evils, and a source of many positive blessings.

Let it not be said, then, that such knowledge is superfluous to the non-medical reader. Society groans under the load of suffering inflicted by causes susceptible of removal, but left in operation in consequence of the prevailing ignorance of our own structure, and of the relations of the different parts of the system to each other and to external objects. Whether we consider the pressing evils to which many operatives are habitually exposed in the exercise of their various trades, without any attempt being made to apply the resources of knowledge to their relief or protection; or whether we contemplate the thousand forms in which the seeds of disease are allowed to be scattered about, especially in our larger towns, when even a small amount of physiological knowledge among the public would almost ensure their speedy removal, we cannot but feel greatly surprised that so little should have been done, during so long a time, to dissipate that ignorance from which, not the poor alone, but the noble and the wealthy, have often extensively suffered. In this respect medical men have, I fear, been much to blame. They alone were the possessors of the knowledge required, and they alone could fully appreciate its value; and yet they have rarely made any effort either to diffuse it more widely, or to rouse attention to its importance. On the contrary, they have, to a considerable extent, neglected its many valuable applications to the prevention and removal of disease, and in their personal conduct set an example of the habitual neglect of its plainest precepts, which has not been without a baneful influence on the public mind.

If, indeed, the more enlightened members of the medical profession had acted under a due sense of their responsibility and obligations to society, and had exerted themselves to diffuse around them a knowledge of the elementary truths of physiology, the public could never have remained so long absolutely blind to the misery, disease, and mortality engendered by the filth, bad ventilation, imperfect drainage, and inadequate supplies of water and food, to which the labouring classes, even of the agricultural districts, are so extensively subjected. That the apathy complained of proceeded from ignorance alone, and not from indifference to the sufferings of our fellow-creatures, may fairly be presumed from the exertions now making by both the Government and the community at large to improve the public health, and elevate the physical condition of the lower orders, as the first step towards securing their moral and intellectual advancement. When the first edition of this work was published in 1834, physiology was considered as a subject altogether unfit for general study, and the utmost indifference prevailed on all questions connected with its application to the prevention of disease. In proportion, however, as knowledge has been diffused, a most favourable change of opinion has taken place, and now there is almost a rivalry between the profession, the Government, and the press, which of them shall contribute most efficiently to the end in view. Thanks to the rapid diffusion of knowledge which is now going on, we may hope that in a few years we shall cease to hear of cases (still too frequent among us) of rational but ignorant men losing their lives by shutting themselves up with lighted stoves or fires in small and almost air-tight cabins, as if for the purpose of committing suicide; or of new-born infants being killed by exposure to the cold in winter, as is still a common occurrence in France, from their being carried, in compliance with the law, to the office of the *maire* for registration. Nor is it likely that there will be many repetitions of such painful catastrophes, as that which happened on board the steamship Londonderry on the night of the 1st December 1848, when 70 out of 150 passengers were suffocated in consequence of being crowded together in a cabin measuring 18 feet in length, by 10 or 12 in breadth, and 7 in height. Nothing but the grossest and most culpable ignorance can account for such events; and considering that medical men are at present the only channels through which the public can obtain that knowledge which is the best protection against their recurrence, a heavy responsibility devolves upon those among them who neglect to exercise their legitimate influence in directing public attention to this study.

Few non-professional persons are aware of the full extent of the evil which results from the habitual neglect, among the people, of the laws of physiology; for notwithstanding all that has hitherto been done to remedy this neglect, and to bring these laws into general practical application in the routine of every-day life, we stand as yet but upon the threshold of improvement. How much remains to be done will be apparent from a consideration of the following details.

It appears from the various reports of the Registrar-General, that the annual rate of mortality for the whole of England and Wales is 1 in 46; but this general rate of the whole kingdom is subject to great variations in different localities, according to the various influences which act on the health of the community. Thus in some of the large manufacturing towns, such as Manchester, Liverpool, Glasgow, and Leeds, the rate of mortality is so high as 1 in 30: while, on the other hand, in the more healthy rural and suburban districts, it falls to 1 in 60, and occasionally even to 1 in 67. From some disturbing causes, which it is unnecessary here to particularise, the difference between the health of urban and rural populations is not so great as these figures would imply; but after every correction has been made, it remains undeniable that there occurs in the cities a large annual loss of life beyond that to which the inhabitants of the country are subject, and which is in a great degree capable of being removed by proper sanitary regulations. But there is no reason to suppose that even in rural districts the people enjoy the maximum degree of health, and that the actual mortality may not be reduced. So far, indeed, is this from being the case, that Mr Simon, in his First Report to the Commissioners of Sewers for the City of London, is sanguine enough to express the belief that the mortality of the City itself may, by judicious sanitary measures, be reduced from 1 in 30 (in 1848–49) to 1 in 66, or considerably below the average rural rate. But if, without venturing to entertain such pleasing anticipations, we assume merely that sanitary legislation is capable of effecting a reduction in the general rate of mortality to 1 in 50, it will follow that, in a population of 16,000,000, the annual saving of human life in England and Wales will amount, in round numbers, to 30,000; and, if the calculation be extended, on the same basis, to Scotland and Ireland, the number of lives annually saved in the United Kingdom will amount to 50,000. Moreover, it has been calculated that for every case of sickness which terminates in death there are twenty which recover; and, if we admit this proportion as approaching the truth, there are thus found to afflict annually the people of Great Britain and Ireland the *avoidable evils* of about fifty thousand deaths and a million cases of sickness, with all their concomitant pain and misery, and their melancholy train of poverty, orphanage, and widowhood—the progeny of mere neglect of the laws of health.*

For evidence of the evils consequent on the deficiency of physiological knowledge even among those who have received a good general education, I may refer to the lamentable ignorance displayed in Parliament, by very intelligent men, during the frequent discussions which took place a few years ago on the regulation of infant labour in factories and mills. Previously to 1833, the law authorised the working of children between the years of eight and sixteen, in the close, heated atmosphere of a cotton mill, for 12 hours a-day; and as a great boon, by the Factories' Regulation Bill passed in that year, no children were to be employed under nine years of age, while, between that and fourteen, the period of daily labour was not to exceed eight hours. Had our legislators been instructed in anatomy and physiology so far as to obtain even the most general notion of the constitution of the human body, and had they been aware of the intimate dependence of the mind on the condition of the bodily organism, they would at once have perceived the destructive tendency of the former system of labour and confinement, and the impossibility of combining with it that moral and intellectual cultivation which is so imperatively required. Instead of objecting to the limitation when it was proposed, they would have looked forward with dread to the physical and moral degradation which the system then in operation was calculated to effect in the multitudes under its influence; and their only doubt would have been, whether even *eight* hours' labour in a close atmosphere was not too much for undeveloped children, and was not incompatible with that efficient moral and general training in the domestic circle, which is indispensable to the development of our best feelings, and consequently to the formation of peaceful, moral, and intelligent citizens. It is true that there were great difficulties in the way of the contemplated restriction, and that in the case of *adult* labour the principle of direct legislative interference is at once unsound and dangerous. But the question assumes a different aspect when it relates to the regulation of labour at an age when those, whose safety and welfare are directly at stake, are incapable of judging for themselves, and are under the absolute control of their parents, who, however influenced by affection, are in general too unenlightened, and too much interested in the immediate profit, to be impartial in their decision. Had natural affection alone proved to be a sufficient protection against the abuse of infant-labour in factories, no application to Parliament on the subject could ever have been required, because in that case no considerable abuse could have taken place. But dire experience has demonstrated that, under the present system of pressure and competition for employment, mere parental feeling is *not* an adequate safeguard, and that there was an absolute necessity for the measures which have been adopted for the protection of the young.

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* For more ample details, see an instructive article in the British and Foreign Medico-Chirurgical Review, vol. i. p. 1.

Since the preceding remarks were first published, their accuracy has been confirmed by many men of experience, and among others by Mr Leonard Horner, who tells us* that all the ominous predictions of ruin and misery made by many of the manufacturers, when contending against any legislative interference for the purpose of limiting the working hours of the children, have been entirely falsified, and that most of them are now satisfied that the law has been *beneficial even to themselves.* Indeed so satisfactory in its results was the practical working of the law, that in 1847 it was deemed right to extend the legislative interference, and accordingly the "Ten Hours' Bill" was introduced into Parliament. By this it was enacted that the labour of all young persons between 13 and 18 years of age employed in cotton-factories, and of all women so employed, should be limited to 10 hours a-day. The minimum age of 13, at which a child might work in the cotton-factories, was in the case of silk-factories reduced to 11, on account of the cleaner and healthier nature of the employment. No interference was attempted with adult male labour, the object of the legislature being to protect those only, who, from their position as wives and children, were subject to the will of others. But the Act had been but a short time in operation when some of the mill-owners, who were opposed to its provisions, found means to thwart the intentions of the legislature by working their mills on what is called the relay-system, by which the women and children, though not actually working more than ten hours, were detained in the mill, and prevented from making a proper use of the time which was intended for relaxation and instruction. To remove the doubts which impeded the working of the Act, recourse was had to fresh legislation, and a new bill was introduced in the session 1849–50, when, owing to the powerful opposition of the mill-owners, the limited period of ten hours was extended to ten and a half. The time during which the "Ten Hours' Act" was in operation, was too short to test the effects of the limitation of the working hours on the capital and commercial enterprise of the country; but there was already evidence to shew that it exerted a beneficial influence on the operatives, by a large majority of whom it was hailed as a great boon, though a reduction of wages had pretty generally followed. Mr Saunders, the Inspector of the London and Leeds District, describes the effects of the working of the Act of 1833 to have been increased health and strength of the children, absence of cases of injury from excessive labour, and a great diminution in the number of accidents, from sleep less readily overtaking the wearied children. There can be no doubt that these beneficial results would have increased under the working of the "Ten Hours' Act;" but the question was viewed by many of the mill-owners in a purely mercantile spirit, and they lost sight not only of the interests of the operatives, but of the well-being of the community at large. They seemed to forget that the human body is liable to be injured in constitution by excess of labour, and that a deteriorated constitution is handed down to the succeeding generation. It is chiefly for this reason, that in France the returns of the conscription are found to give, in the manufacturing districts of the country, a much higher proportion of young men incapable of military service from deficient stature and feeble constitution, than in the agricultural districts.

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* On the Employment of Children in Factories and other Works. Longman and Co. 1840.

In those numerous instances, again, in which it would be not less futile than impolitic to attempt to remedy a great social evil by direct legislation, the general diffusion of physiological knowledge acquires even greater importance, because our only resource then consists in an appeal to enlightened and well-directed public opinion. Let us take as an example the unfortunate shirt and trouser makers and milliners of the metropolis. From the *Report of the Children's Employment Commission*, published several years ago, we find that in London about 15,000 young females are engaged in these occupations, and that "in some of what are considered the best-regulated establishments, during the fashionable season (occupying about four months in the year), the regulated hours are fifteen, but in emergencies, which frequently occur, these hours extend to eighteen. In many establishments, the hours of work during the season are unlimited, the young women *never* getting more than six, often not more than *four*, sometimes only *three*, and occasionally not more than *two* hours for *rest* and *sleep* out of the twenty-four, and *very frequently they work all night.*" Miss ———, of Welbeck Street, *an employer*, confesses that in "the drive of the season," the work is occasionally continued *all night three times a-week.* In some houses which profess to study the health of their young people, they begin at 4 A.M. and leave off at 11 P.M., *never earlier.* One witness stated that she had herself worked *twenty hours out of the twenty-four* for three months together; and when her medical adviser remonstrated against this on account of her health giving way, his services were dispensed with by her employer. Here certainly is a state of things which calls loudly for a remedy; and if there are insuperable objections against direct legislative interference, it surely becomes doubly imperative to promote the wider diffusion of that physiological knowledge, from which alone a corrective for so monstrous an evil can be obtained. It may be traced directly to ignorance and short-sighted selfishness, rather than to any perverse love of cruelty and oppression; and the most effectual as well as the safest way to put it down is to strike at its root. By a compulsory restrictive enactment, we may succeed in partially suppressing the evil or hiding it from public view; but so long as its causes are left in operation, it will be ever ready to spring up with redoubled force in some new direction. The letters on "Labour and the Poor," published in 1850 in the *Morning Chronicle*, lift up the veil which hid the miseries of the destitute, and disclose an amount of wretchedness which it is difficult to conceive. It appears that in London alone there are 35,000 women engaged in "slop-sewing," and that of this number 28,500 are under twenty years of age, living, or rather attempting to live, on sums varying from 4½d. to 2½d. a-day! Where is the remedy for such a state of things to be found? Alleviating and temporary measures may be sought in emigration, and the efforts of Lord Ashley and Mr Sidney Herbert to raise a fund for this purpose are worthy of all support. But this resource will leave the causes of the distress still in vigorous action, and no permanent good will result till the axe be laid to the root of the evil. This can be done by education only. The multitudes who, sunk in ignorance, now display mental qualities often less respectable than those of the lower animals, must be raised by education to the rank of moral and intelligent beings, to a feeling of responsibility and self-respect; they must be taught to curb their passions, and to bear in mind the duties they owe to God and to their fellow-men. A broadly-based system of National Education is the first step towards the permanent improvement of the working-classes. A man must be trained to use his faculties, precisely as a mechanic is trained to use his tools. With increased knowledge will come increased power and opportunity of gaining subsistence; wider fields of exertion will be opened, and a permanent check will be given to that reckless indulgence of the natural appetites which constitutes the main source of the destitution and wretchedness that are at present sapping the foundations of society.

CHAPTER II.

CAUSES OF THE NEGLECT OF PRACTICAL PHYSIOLOGY IN SOCIAL LIFE. —SLOW AND INSIDIOUS ORIGIN OF DISEASE.

CONSIDERING the deeply interesting character of physiology as an exposition of the nature and functions of the animal economy, it may seem strange that the study of its numerous practical applications should have been so long and so generally neglected. Several causes have contributed to this result, and among these, perhaps the most influential has been the fact that physiology itself is almost a new science, and as such exhibits many imperfections. The rapid rate, however, at which physiological discovery is now advancing, is continually removing this reason for indifference; and in a short time we may hope to see ample provision made in every medical school for imparting to the profession, and through it to society at large, that information which is at present so much wanted regarding its numerous applications to the preservation and recovery of health, and to the general improvement of man.

The very gradual way in which most external influences produce their effects on the bodily constitution, has been another cause of the neglect of physiology by the profession as well as by the public. When a man loses his life in consequence of sudden immersion in the carbonic acid of a brewer's vat, every body perceives at once the existence of a sufficient cause for the result, and can trace its mode of action in the extinction of life. But when a person is subjected to the action of the same gas in a more diluted form, as in the confined atmosphere of an ill-ventilated apartment, public assembly-room, or crowded church, the effect produced on the bodily system is much less in degree, and instead of actual destruction of life, it may amount only to a sense of uneasiness, oppression, or headach, which is disagreeable at the time, but which goes off on the admission of pure air. No *sensible* inconvenience continuing afterwards to be felt, the conclusion is drawn, that the exposure has done no harm; and hence no effort is made to avoid or prevent its repetition. In fact and in reason, however, the evil done is *quite as certain* in the one case as in the other. The only difference is, that, in the one, the feeble, because diluted, poison produces a correspondingly smaller effect; while in the other, the concentrated poison produces a result so intense that there is no possibility of overlooking it. But let the weaker poison *continue* to act, as when an individual lives habitually in a vitiated atmosphere, and the sum of weak effects will go on constantly accumulating, till health becomes impaired by slow degrees, and premature death at last ensues, as certainly, though not so soon, as in the other case. Circumstances may more or less retard or modify the result; but the tendency of the vitiated air to undermine health, although more palpable to our senses in the one case than in the other, is exactly the same in both. It is from giving attention only to the more striking cases, and overlooking the operation of the more permanent though slowly acting influences, that so many persons when in health fail to perceive the effect of external circumstances and modes of living in disturbing the actions of the various animal functions, however easily and deeply the very same persons may be impressed by all *extraordinary* occurrences affecting them. Thus, when any one is taken ill, his relatives or friends become extremely anxious to have his room properly ventilated, his clothes frequently changed and carefully aired, his food properly regulated in quantity and quality, his skin cleaned and refreshed, his mind amused and tranquillized, his sleep rendered sound and undisturbed, and his body duly exercised;—and they state as the reason for all this care, and most justly, that pure air, cleanliness, attention to diet, cheerfulness, regular exercise, and sound sleep, are all highly conducive to recovery. Yet such is the inconsistency attendant on ignorance, that the patient is no sooner restored than both he and his guardians often become as careless and indifferent in regard to all such acts of obedience to the laws of health, as if their influence had ceased, and their future neglect or observance could in no way affect him! Just as if it were not better, by a rational exercise of judgment, *to preserve health when we have it*, than first to lose it, and then pay the penalty in suffering and danger, as an indispensable preliminary to its restoration!

It is from the same prevailing fallacy of supposing that, because glaring mischief does not *instantly* follow every neglect of an organic law, no harm has been done—that we hear, for example, a dyspeptic invalid who seeks to gratify his palate, affirm that vegetables, or pastry, or puddings, do not disagree with him, as he ate them on such a day and felt no inconvenience from doing so. The same assurance is given us in regard to late hours, heated rooms, insufficient clothing, and all other sources of bad health, every one of which is defended by some patient or other, on the ground that he experienced no injury from them on a *certain specified occasion.* Yet the very same individuals, when the rule is applied, not to themselves, but to others, will often readily admit that such things are, and *must be,* very hurtful.

Happy would it often be for suffering man could he see beforehand the modicum of punishment which his multiplied aberrations from the laws of physiology are sure to bring upon him. But as, in the great majority of instances, the breach of the law is limited in extent, and becomes serious only by the frequency of its repetition, so is the punishment gradual in its infliction, and slow in manifesting its accumulated intensity; and this very gradation, and the distance of time at which the full effect is produced, are the reasons why man in his ignorance so often fails to trace the connection between his conduct in life and his broken health. But the connection subsists although he does not regard it, and the accumulated consequences come upon him when he least expects their appearance.

It is precisely in the same way that the debility so generally complained of in spring by invalids and persons of a delicate constitution, and which renders that season of the year so formidable in prospect and so fatal in reality, seems, in numerous instances, to result more from the accumulated effects of neglect during the preceding winter months, than from any thing inherent in the season itself. At the commencement of winter, such persons feel comparatively strong from the beneficial influences of the open air, light, and exercise, which they have enjoyed during the summer and autumnal months. But, in proportion as they are deprived of these benefits by the advance of winter, and are subjected to the evil consequences of confinement, deficient exercise, cold, damp air, and deprivation of the stimulus of light, the strength of the constitution becomes impaired, and debility and relaxation begin to be felt, and make progress from day to day, till, on the arrival of spring, they have reached their maximum, and then either give rise to positive disease, or again gradually disappear on the return of the invigorating influence of longer and warmer days.

In strict accordance with this view, it is stated by Lugol as the result of very extensive observation, that the first attack of *scrofula* generally "*occurs in spring, and that every year in spring a recrudescence* (or fresh outbreak) *takes place.* This recrudescence commences as the days begin to lengthen, that is, about the month of January. The maximum is in the month of March, from which date until the month of June, the intensity of the disease gradually decreases. *Nine-tenths of the persons affected with scrofula present this annual exacerbation.*"* I need not point out how completely these results bear out every word of the preceding paragraph, written years before the work from which the extract is taken was published. My views on this subject are supported also by the statistical researches of M. Moser, and of M. Quetelet. The former, taking for the basis of his calculations the register of mortality of the city of Königsberg, found that the month of February was most fatal to young children, and adults past their prime; while March and April shewed a greater mortality of persons of the intermediate age. M. Quetelet's researches are more minute, and still more conclusive. It appears from them that the greatest mortality of children under 2 years of age occurs in January, of those between 2 and 3 years in March, between 3 and 12 years in April, and between 12 and 16 years in May; the period of greatest mortality thus always receding as the vigour of the system increases.* On a larger scale the returns of the Registrar-General point to the same truth, by shewing that when no violent disturbing causes, such as pestilence or famine, interfere, the largest number of deaths takes place in England and Wales during the quarter ending 31st March. The average number of deaths in each of the four quarters of the four years 1838–41 was, in the

1st quarter—97,765
2d quarter—89,141
3d quarter—75,707
4th quarter—83,639†

The influence of cold and diminished light, and of overcrowding for the sake of warmth, are thus strikingly shewn by the increased mortality of the colder months. "A fall of the mean temperature of the air," says the Registrar-General, "from 45° to 4° or 5° below the freezing point of water (32°) destroys (in a week) from 300 to 400 lives in London."‡

It seems, therefore, obvious that, in most cases, the hurtful cause is not, as is commonly supposed, so much any positive quality of the season, as the accumulated mass of the winter influences then reaching its maximum; and this is not perceived, only because the effect from day to day, although perfectly real, is too small to attract notice, while the aggregate result of the many days composing winter is striking enough. The feeble in constitution give way first; those who are stronger offer a longer resistance. The fact that persons who deny themselves the delight of late parties and crowded rooms, and are sufficiently robust to undergo the necessary exposure in winter, suffer much less in spring, corroborates the explanation we have given.§

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* Lancet, 22d June 1844, p. 417.

* Levy, Traité d'Hygiène, vol. ii. p. 499. Paris, 1845.

† Fifth Annual Report, p. x.

‡ Eighth Annual Report, p. xxxvii.

§ Although it is true that the east winds prevalent in spring are of themselves injurious in cases of pulmonary disease or great susceptibility of the constitution, this fact is nowise inconsistent with the opinion here advanced. In every instance, the

Of the truth and practical value of the views above expressed, the author may be allowed to quote his own case as an instructive example. In 1820 he began to suffer from illness of a consumptive character, which caused his life to be despaired of. At the end of three years he had gradually regained a state of health sufficient to enable him to engage in practice, but far short of what had been usual with him before his illness. In 1831, after an interval of nine years, a second attack of the same character supervened, and forced him again to go to a milder climate. In January and February 1832 his condition was such as to leave little hope of his surviving the spring. Aware that his only chance lay in assisting nature to the utmost extent by placing every organ in the circumstances best fitted for the healthy performance of its function, he acted habitually on the principle of yielding the strictest obedience to the physiological lawsand rendering every other object secondary to this. He did so in the full assurance that, whether recovery followed or not, this was, at all events, the most certain way to secure the greatest bodily ease and the most perfect mental tranquillity compatible with his situation. The result was in the highest degree satisfactory. From the condition of being obliged to pause twice in getting out of bed, a slow but progressive improvement took place, and by long and steady perseverance continued till, at the end of two or three months, he was able to drive out and walk a little every day. From month to month afterwards, the amendment was so gradual as to be scarcely perceptible; but at the end of a longer period the difference was striking enough. Thus encouraged, he continued true to his principles, and firm in resisting every temptation to which improving health exposed him: and the result was, that, with one or two exceptions, every successive year from 1832 up to January 1841 found him more healthy and vigorous than before, and that many of his professional friends who long regarded his partial convalescence as destined to be of very brief duration, could not refrain from expressing surprise on observing it to be still perceptibly advancing at the end of ten years. The disease, it is true, has once more resumed its activity and disabled him for exertion; but again he has derived the greatest benefit from a strict and patient observance of the physiological laws in circumstances of a very unpromising kind. Instead of being cut off in a few months, as from the existing disorganisation his professional friends expected, he is not only still alive (August 1846), but in the enjoyment of a share of health and comfort rarely met with in a frame so radically undermined. The author ventures to publish this example, both because, as an illustration of the advantages of acting in accordance with the laws of our nature, it is as instructive as any with which he is acquainted, and because it strikingly shews the operation of the gradual accumulation of almost inperceptible but ever active influences in surely, though slowly, restoring him to a degree of health and enjoyment which has richly repaid him for all the privations submitted to. Had he not been fully aware of the gravity of his own situation, and, from previous knowledge of the admirable adaptation of the physiological laws to carry on the machinery of life, been disposed to place implicit reliance on the superior advantages of conforming to them as emanations of Divine Wisdom, he never would have been able to persevere in the prescribed course with that steady and long-enduring regularity and cheerfulness which have contributed so much to their successful observance and results. And therefore he feels himself entitled to call upon those who, impatient at the slowness of their progress, can hardly restrain themselves after a time from disregarding all restrictions, to take a

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power of resisting the prejudicial effect of spring weather will be greater or less, according as the laws of physiology have been well or ill observed during the winter months.

sounder view of their true position, to make themselves acquainted with the real dictates of the organic laws, and, having done so, to yield them full, implicit, and persevering obedience, in the certain assurance that they will reap their reward in renewed health, if recovery be still possible; and if not, that they will thereby obtain more peace of mind and bodily ease than by any other means which they can use.*

From the preceding explanation of the slow but gradually increasing effect of both noxious and healthful influences on the human body, it is obvious that while, on the one hand, it would be erroneous to infer that a single application of a remedy, or single fulfilment of a physiological law is useless, merely because no appreciable benefit has instantly ensued; on the other hand, it would be equally erroneous to infer that because a *single* excess of

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* Notwithstanding the author's death, the editor has judged it proper to leave this passage unaltered. To render it still more instructive, he subjoins the further history of the case. Dr Combe continued to enjoy that "share of health and comfort" of which he speaks, till the spring of 1847, when, (having always derived much advantage from sea-voyages, and being desirous to visit a brother who had been many years settled in the United States,) he consulted his medical friends as to the propriety of crossing the Atlantic. Receiving from them no discouragement, he embarked at Liverpool in April for New York. As it happened, the vessel carried a crowd of emigrants, chiefly Irish, who occupied the steerage, which extended the whole length of the ship, and of course partly under the cabin. The partitions and flooring being imperfect, allowed the passage of the foul emanations arising from a large number of individuals, crowded together in a narrow and ill-ventilated hold; and the prolonged respiration, especially during the night, of an atmosphere thus vitiated, exerted a deleterious influence on his constitution and lowered the tone of his system. Accordingly, after a short stay in America, where the season happened to be unusually hot, he returned to Scotland in a less satisfactory state than when he left it. His condition, however, did not become alarming till within eight days of his death, the immediate cause of which was chronic disease of the bowels, which, coming suddenly to a crisis, defied every effort of medical skill, and terminated his existence on the 9th of August, at the age of 49 years. The body was examined about 18 hours after death, by Dr John Scott and Dr Handyside, the former of whom drew up the following report:—

"The skull was remarkably thin and regular in its walls; the internal surface more deeply marked by the blood-vessels than usual; the brain exceedingly healthy.

"The thorax was much contracted on the left side, especially on the superior part, measuring fully two inches less than the right, and being flattened and depressed under the clavicle and the two first ribs. On removing the sternum, the *right* lung was found very large, passing to the left side of the sternum and filling a space in the left side of nearly two inches in breadth, and three in length. The right lung itself was adherent to the pleura costalis by scattered and firm adhesions. The lower surface was more especially attached to the diaphragm by very close adhesions. The lung in its texture was in some places, especially towards the lower part, congested, but everywhere pervious to air, and without any tubercles. The bronchial tubes were firmer and larger than natural.

"The *left* lung was contracted to a very small size, and adherent by very thick and strong false membranes, especially in the summit, to the ribs; the adhesions were so strong that the lung was with difficulty removed. The summit was particularly indurated and infiltrated with black matter, but without any change in its structure. It also contained many large and small caverns. The lung was without any tubercle or cretaceous matter. The surface was black, and this colour was found to pervade the pulmonary texture generally; the cellular appearance was, however, still visible. The upper lobe was dense in structure and hollowed out into numerous caverns opening into each other in some instances, in others single and of smaller size. These extended from the summit of the lung, and chiefly occupied the anterior part, and opposite the first and second rib. The bronchial tubes, some of a large size, opened directly into the caverns and were continuous with them. The longitudinal fibres in the larger bronchial tubes were particularly strong, and the circular ones in the smaller. The caverns themselves were remarkably regular in shape, especially when single, and were lined by a fine, smooth, thin membrane. The opening of both small and large bronchial tubes was easily perceived in them; they were more generally dilatations of the extreme termiany kind does not produce an immediate attack of disease, it therefore must be harmless. For it is only when the noxious agent is very powerful indeed, as in the case of an active poison, that its deleterious influence on the system becomes instantly sensible. In the great majority of situations to which man is exposed in social life, it is *the continued or the reiterated application of less powerful causes* which gradually, and often imperceptibly, unless to the vigilant eye, effects the change, and ruins the constitution before danger is dreamt of. Hence, the great mass of human ailments is of slow growth and slow progress, and admits only of a slow cure; whereas those which are suddenly induced by violent causes, are urgent in their nature and rapid in their course. And yet so little are we accustomed to trace diseased action to its true causes, and to distinguish between *the essential* and *the accidental* in the list of consequences, that, as already observed, if no glaring mischief follow any particular practice within at most twenty-four hours, nine out of ten individuals will come to the conclusion that it is perfectly harmless, even where the reverse is the demonstrable fact.

The benevolence and wisdom of this arrangement are very conspicuous. There are many casual influences from the agency of which man will never be able entirely to protect himself. If they are speedily withdrawn from him, the slight disorder which they produce quickly ceases, and health remains essentially undisturbed. But, if they are left in operation for a considerable length of time, the derangement which they excite increases gradually and slowly, till at last a state of disease becomes established, which requires an equally long or a longer period, and a steady observance of the laws of health, for its removal.

Such is the history of the rise and progress of most of the ailments which afflict the human family, and the source of the grand distinction between *acute* and *chronic* diseases. But from ignorance of physiology, how many are blind to the evil operation of the many local causes of disease by which they are surrounded in ill-drained, ill-ventilated, and ill-cleaned towns! The causes act slowly, and are therefore supposed to be harmless. In drawing this inference people overlook the difference between chronic and acute diseases, and are apt to wonder that a severe disease like inflammation should run its course in a few days, while dyspeptic and nervous ailments require months for their cure. But their wonder would be diminished by attending to the fact, that the one generally dates its rise from a strong cause applied within perhaps a few hours or a few days; while the others are *the slow and gradual results of months or years of previous anxiety or neglect of dietetic rules and exercise, during which the ailment was maturing unnoticed and unsuspected.* Had the real state of the matter been early perceived, and the causes been removed, the dyspeptic and nervous invalids would have regained health and serenity in proportionally little time, and with proportionally little suffering. In such cases, Nature kindly allows some latitude of action free of serious penalty, as if on purpose to protect us from being hurt by such occasional exposure as we are necessarily subjected to by the ordinary vicissitudes of life; but it is always on condition of returning to obedience the moment the necessity is over. If we presume on the indulgence being permanent, the evil will

nations, than merely dilatations, of the large bronchiæ. There was no emphysema.

"The lower lobe was fleshy, pretty firm, but retained more of the natural appearance than the upper. The heart was large, but not diseased. The kidneys seemed natural in structure, but were filled with a greyish-coloured thick fluid. The colon and rectum were thickened throughout, and covered with minute ulcerations, some very small, and others of considerable size. The muscular and mucous coat of the rectum was thickened."

See Life and Correspondence of Andrew Combe, M.D., by George Combe, p. 588 (Edinburgh, 1850); a work which furnishes a detailed history of Dr Combe's case, and of the means by which he so long resisted the disease.

accumulate, and health be destroyed; but if we return in time to the right path, little inconvenience will ensue. Where, however, the injurious influences are of a more energetic kind, equal latitude of exposure is obviously incompatible with safety. Were they not to enforce immediate notice, our corporeal organs might be irrecoverably altered by disease before we took the alarm; and it is therefore the purest benevolence to attach immediate suffering to *them*, in order to ensure that instant attention which alone can stay the rapidity of their progress.

In chronic or slowly arising diseases, then, the separation of the effect from its cause is only apparent and not real; and in practice it is essential to keep this in mind. A fit of insanity, for example, is often said to have come on *without any cause*, when, on minuter examination, causes can be easily traced operating through many previous months, only not of so violent a nature as to have at once upset reason. The same will be found to hold in almost all those slow and insidious illnesses which so often baffle our best efforts; and although at present we cannot always discover their true origin, it is clear that we shall ultimately succeed much better if we believe them to have causes which *may* be found out, than if we regard them as mysteries which no amount of study or attention can ever enable us to explain.

It is this apparent but unreal separation of the effect from its cause, which has given rise to the variety of opinions entertained in regard to the qualities of the same agents, and which has, perhaps, tended more than anything else to discourage rational regard to the means of preserving health; and led us practically to look upon the effects of air, food, exercise, and dress, as very much matters of chance, subject to no fixed rule, and therefore little worth attending to, except when carried to palpable extremes, or in the cure of disease. But were the generality of intelligent persons better acquainted with the functions of the human body, and their laws, many of these anomalies in practice would disappear; the sources of much suffering would be dried up, and the happiness of the community at large be essentially promoted. Medical men would no longer be consulted so exclusively for the *cure* of disease, but would also be called upon to advise regarding the best means of strengthening the constitution, from an early period, against any accidental or hereditary susceptibility which might exist. More attention would be paid to the *preservation* of health than is at present practicable; and the medical man would then be able to advise with increased effect, because he would be comparatively well understood, and his counsel, in so far at least as it was based on accurate observation and a right application of principles, would be perceived to be, not a mere human opinion, but in reality an exposition of the will and intentions of a beneficent Creator, and would therefore be felt as carrying with it an authority to which, as the mere dictum of a fallible fellow-creature, it could never be considered as entitled.

Even as regards recovery from disease, the importance of keeping up a habitually good state of health can scarcely be over-rated; because the state of the constitution at the time of the attack exercises a marked influence over the resulting mortality. Hence, when an epidemic seizes on an enfeebled population, the number of victims is always proportionally large. This was exemplified, for instance, in Manchester and its suburbs, where, from deleterious influences, the mortality, under ordinary circumstances, is about double that of the healthiest parts of the country. In the quarter ending September 30, 1846, the mortality rose, under the influence of epidemic disease, from 2411, the mortality of the corresponding quarter of the preceding year, to 4248; while the mortality of the rural district of Anglesea, with a population of about a tenth of that of Manchester, was only 149 and 160 for the same periods. Another illustration is afforded by the fearful ravages which cholera committed, in 1849, among the half-starved children at Tooting, and the debilitated paupers of the Taunton workhouse. It is not therefore surprising to find the experienced and sagacious Louis remarking, that although inflammation of the lungs is a very serious and often fatal disease, it almost always terminates favourably *when it occurs in persons previously healthy;* and that, under the same conditions, he had never known erysipelas of the face, or enteritis, prove fatal.* So also it is notorious, that in an unhealthy state of the body, the slightest accident, or attack of disease, will suffice to cause death. A mere scratch on the finger, a common cold, or a little irritation in the bowels, will often, in such circumstances, terminate fatally; while, in an opposite or sound state of the system, the severest accidents, or attacks of acute disease, may be encountered with little risk of death, or even of permanent bad consequences. With facts like these before our eyes, it is strange indeed, that medical men should have devoted so little attention to the means of preserving or improving the physical well-being of the race—a subject to which even the ancient philosophers and physicians attached the highest importance, and which they justly considered as falling directly within the province of the medical practitioner. Nothing can shew more strikingly the little value hitherto attached to the practical uses of physiology, than the fact that even yet there is scarcely a medical school in this country in which the science of preventive medicine is brought specially under the notice of the student. In some of the foreign universities, however, it has long constituted an essential part of medical education; and in France, a journal of Hygiène has existed for several years. But in this country, with the exception of the London University, which, since the publication of the early editions of this work, has done itself honour by being the first institution in Britain to require an acquaintance with Hygiène from intending candidates for its diploma, the subject has nowhere been treated with anything like the regard which it assuredly deserves.* The result of this serious omission is, that the young practitioner is educated without having made himself sufficiently familiar with the conditions on which the *healthy* action of the animal economy depends, or having even rightly appreciated the importance of such knowledge; so that, in common with his patient, he not only neglects the important agency of hygienic influences in the cure of disease, but sometimes unwittingly allows the operation of morbid causes to go on without interference, where, by a timely warning on his part, serious illness might be averted—or unconsciously permits the gradual ripening of hereditary tendencies into active disease, which rational precautions, early resorted to, might have kept in subjection through many years. "It is much more rational," says Professor Mulder of Utrecht, "to prevent than to cure disease. For myself, if it were a matter of choice, I would much rather see *preservers of health* than *curers of disease* among us, although it is certainly most desirable that there should be both. It is unfortunately the case, however, that at none of our universities is instruction provided for the former."† But the day is perhaps not far distant, when a degree of importance will be ascribed to the practical application of the doctrines of Hygiène, far surpassing what those who have not reflected on the subject may think it deserves. In the case of the lower animals, the necessity of modifying the method of rearing according to the peculiarities of constitution which they present, has long been perceived and consistently submitted to in practice; and the extent to which we can thus secure the development and efficiency of almost any organ and quality, has often been the theme of admiration and surprise. There can scarcely be a doubt that were physiological principles followed to an equal extent in the cultivation of the physical, moral, and intellectual powers of man, a corresponding degree of success would reward our exertions in his improvement.*

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* Lancet, ii. p. 107.

* The London Monthly Journal of Public Health (1848-9), though ably conducted, had but a short existence.

† Die Ernährung in ihrem Zusammenhange mit dem Volksgeist, p. 13.

It is true that many medical men, sooner or later, work out a practical knowledge of physiology for themselves; but I have no hesitation in saying that these are exceptions to the general rule, and that the greater number pass through life without a conception of its real value. Even those who ultimately become familiar with the subject, almost always attain their knowledge only after having suffered from the want of it; and rarely master it so completely as they would have done had it been made a part of their elementary education, to which they saw others attach importance. In my own instance, it was only after having both suffered in health myself, and had some experience in practice, that I had occasion to feel and to observe the evils arising from the ignorance which prevails in society regarding it.†

The practical neglect of physiological knowledge in the training and education of the young, and especially of medical students, appears to me to have arisen to a great extent from the unnatural separation of the different branches of medical science from each other by their cultivators and teachers, and the exclusive devotion of each to his own favourite department. So far, indeed, has this separation been carried, and so injurious is the consequent habit of contemplating objects from the narrowest point of view, that I have known a very able teacher of physiology, in his public lectures, ridicule the very notion of laying down general rules for the preservation of health, and imagine that he set the matter entirely at rest by the simple assertion that *variety* is advantageous, and that, therefore, *uniformity of obedience to any rules must be prejudicial*—as if it were not of the very essence of general laws to be modified in their operation and results by the circumstances under which they act; and as if, because of such modifications, their influence might with safety be entirely neglected.*

Many, however, who are fully sensible of the value of health, are still haunted by the notion that to teach any one how to take care of his own health is sure to do harm, by making him constantly think of this and the other precaution, to the utter sacrifice of every noble and generous feeling, and to the certain production of hypochondriacal peevishness and discontent. The result, however, is exactly the reverse; and it would be a singular anomaly in the constitution of the moral world were it otherwise. He who is familiarly acquainted with grammar and orthography, writes and spells so easily and accurately as scarcely to be conscious of attending to the rules by which he is guided; while he, on the contrary, who is not instructed in either, and knows not how to arrange his sentences, toils at the task, and sighs at every line. The same principle holds in regard to health. Whoever is acquainted with the constitution of the human body, and with the laws of its action, sees at once his true position when exposed to the causes of disease, decides what ought to be done, and thereafter feels himself at liberty to devote his undivided attention to the calls of higher duties. But it is far otherwise with the man who is destitute of this information. Uncertain of the nature and extent of the danger, he knows not to which hand to turn for safety, and either lives passively in the fear of mortal disease, or, in his ignorance, resorts to irrational and hurtful precautions, to the certain neglect of those which he ought to use. It is ignorance, then, and not knowledge, which renders an individual full of fancies and apprehensions, and robs him of his usefulness. It would be a stigma on the Creator's wisdom if true knowledge weakened the understanding and led to injurious results. And accordingly, the genuine hypochondriac, whose blind credulity leads him to the implicit adoption of every monstrous specific, is not the man who has gained wholesome knowledge by patient study in the field of nature—but he who has derived his notions of the human constitution, and of the laws of nature, from the obscure recesses of his own unenlightened imagination.

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* This opinion is powerfully advocated and illustrated in an American work, entitled "Thoughts on Physical Education and the True Mode of Improving the Condition of Man. By Charles Caldwell, M.D., Professor of the Institutes of Medicine and Medical Jurisprudence, Louisville, Kentucky. Second British Edition; with a Preface by George Combe." Edinburgh, 1844.

† See a fuller statement of Dr Combe's views on this subject in his letter to Sir James Clark "On the Importance of Hygiène as a Branch of Medical Education," forming the 19th chapter of his Life and Correspondence.—Ed.

* The lecturer above alluded to afterwards changed his opinions so far, as not only to deliver a course of popular lectures on Physiology, but to publish in favour of its being considered an indispensable branch of general education.

If, indeed, ignorance were itself a preventive of the danger, or could provide a remedy when it approached, then might we readily allow that "ignorance is bliss;" but as it gives only the kind of security which shutting the eyes affords against the dangers of a precipice, and thus leaves its victim doubly exposed, it is high time to renounce its friendship and protection, and to seek the support of a more powerful and beneficent ally. If ignorance could divest us even of the sense of anxiety attending the apprehension of evil, the consequent tranquillity of mind, deceptive though it were, would be at least some compensation for submitting to its rule. But, unhappily, so far from ignorance of the nature and extent of the threatening danger saving us from gloomy anticipations, the fact is notoriously the reverse; for the darkest picture ever drawn is assuredly that delineated by an ill-directed imagination. Every medical man can testify that, natural character and other circumstances being alike, those whose knowledge is the most limited are the fullest of whims and fancies, the most alarmed at every trifling ailment, the most credulous respecting the efficacy of every senseless and preposterous remedy, the most impatient of restraint, and the most discontented at suffering. There are some, no doubt, whose constitutional excitability prevents them from ever controlling their feelings, or being guided by the dictates of reason; but such persons are comparatively few, and even they become more tractable as well as more comfortable in spirit, when their minds are enlightened, and their true situation is distinctly understood.

Happily for mankind, the "dangers of knowledge" are now so little dreaded in comparison with the certain evils of physiological ignorance, that while the number of objections against its general diffusion is every day becoming smaller, the number of its advocates is increasing in tenfold proportion, especially among the highest class of minds. Of this truth we have an illustrious example in the late Dr Channing, whose tendency was rather to depreciate the material part of our nature, and who was thus unlikely to attach undue importance to the preservation or improvement of the bodily health. In his second Lecture on the Elevation of the Working Classes, he eloquently and forcibly expresses his belief that "the great cause of the depressed condition of not a few labourers is their *ignorance on the subject of health.* Health is the working man's fortune, and he ought to watch over it more than the capitalist over his largest investments. Health lightens the efforts of body and mind. It enables a man to crowd much work into narrow space. For these reasons I cannot but look on it as a good omen, that the press is circulating among us cheap works, in which much useful knowledge is given of the structure, and functions, and laws of the human body. It is in no small degree through our own imprudence, that disease and debility are incurred; and our remedy is to be found in knowledge. Once let the mass of the people be instructed in their own frames; let them understand clearly that disease is not accident, but has fixed causes, many of which they can avert, and a great amount of suffering, want, and consequent intellectual depression, will be removed. . . . I hope I shall not digress too far when I add, that were the mass of the community more enlightened on these points, they would apply their knowledge not only to their private habits, but to the government of the city, and would insist on municipal regulations favouring general health."*

It would be difficult to add to the cogency of these remarks of one whose whole life was devoted to the improvement of his race; but if any of my readers be still doubtful of the propriety or safety of communicating physiological knowledge to the public at large, and think that ignorance is in all circumstances to be preferred, I would venture to ask him whether, on the occasion when cholera made its first appearance, it was knowledge or ignorance which induced the poorer classes in every country of Asia and of Europe to attempt to protect themselves from its ravages by committing outrages on the medical attendants of the sick, under the notion of their having poisoned the public fountains? and whether it was ignorance or knowledge which prompted the more rational part of the community to seek safety in increased attention to proper food, warmth, cleanliness, and clothing? In both classes, the desire of safety and the sense of danger were the same, but the modes resorted to by each were as different in kind as in result; the efficiency of the one forming a glaring contrast to the failure of the other.

The foolish notion is now happily on the decline, that to take care of one's health is selfish and ignoble. So far is a rational attention to health from being justly liable to such an imputation, that in fact there is nothing which tends so much to relieve society from the burden of miseries not its own, as each individual taking such care of his constitution as shall enable him to cope successfully with the duties and difficulties of the situation in which he is placed. No man is so *thoroughly selfish* as he who, in the ardent pursuit of pleasure or of profit, heedlessly exposes his life to the hazard of a die, regardless of the suffering which he may entail upon those who depend on him for support. In the abstract, we all admit that the enjoyment of health is the first of earthly blessings, and that without it all others may be lavished on us in vain; and yet it has been quaintly asked, "Who is he that values health at the rate it is worth? Not he that hath it; he reckons it among the common ordinary enjoyments, and takes as little notice of it, or less regards it, than his long worn clothes: perhaps more careful of his garments, remembering their price; but thinks his health costs him nothing, and coming to him at so easy a rate, values it accordingly, and hath little regard to keep it: is never truly sensible of what he enjoyed until he finds the want of it by sickness; then health, above all things, is earnestly desired and wished for."

In proportion, however, as we consider the matter with that attention which its importance really deserves, we shall become anxious rather to take care of health when we have it, than first to lose it, and then exert ourselves to recover it. Such was evidently the feeling which elicited the following remarks from the clear-sighted author who has just been quoted.

"You that have health," says he, "and know not how to prize it, I'll tell you what it is, that you may love it better, put a higher value upon it, and endeavour to preserve it with a more serious, stricter observance and tuition.

"Health is that which makes your meat and drink both savoury and pleasant, else Nature's injunction of eating and drinking were a hard task and slavish custom.

"Health is that which makes your

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* Channing's Works, vol. v. p. 215.

bed easy and your sleep refreshing; that revives your strength with the rising sun, and makes you cheerful at the light of another day; 'tis that which fills up the hollow and uneven places of your carcass, and makes your body plump and comely; 'tis that which dresseth you up in Nature's richest attire, and adorns your face with her choicest colours.

" 'Tis that which makes exercise a sport, and walking abroad the enjoyment of your liberty.

" 'Tis that which makes fertile and increaseth the natural endowments of your mind, and preserves them long from decay, makes your wit acute, and your memory retentive.

" 'Tis that which supports the fragility of a corruptible body, and preserves the verdure, vigour, and beauty of youth.

" 'Tis that which makes the soul take delight in her mansion, sporting herself at the casements of your eyes.

" 'Tis that which makes pleasure to be pleasure, and delights delightful, without which you can solace yourself in nothing of terrene felicities or enjoyments."

But " now take a view of yourself when health has turned its back upon you, and deserts your company; see then how the scene is changed, how you are robbed and spoiled of all your comforts and enjoyments.

" Sleep that was stretched out from evening to the fair bright day, is now broken into pieces, and subdivided, not worth the accounting; the night that before seemed short is now too long, and the downy bed presseth hard against the bones.

" Exercise is now toyling, and walking abroad the carrying of a burthen.

" The eye that flasht as lightning is now like the opacious body of a thick cloud; that rolled from east to west, swifter than a celestial orb, is now tired and weary with standing still; that penetrated the centre of another microcosm, hath lost its planetary influence, and is become obtuse and dull," &c.

If such, then, be a true picture of the opposite conditions of health and disease, what stronger inducements can any one require to give him an interest in the " study and observance of Nature's institutions," seeing that they are the only means by which " the beloved ends and wished-for enjoyments" can be attained, and that we " may as likely keep or acquire riches by prodigality, as preserve health and obtain long life by intemperance, inordinate passions, a noxious air, and such like injurious customs, ways, and manner of living?"*

In thus strongly advocating the benefits to be obtained by the wide diffusion of a general knowledge of the laws of health, I must, however, express my belief that the study of *diseases*, and their modes of cure, by unprofessional persons is not only unprofitable, but often deeply injurious —just because such persons cannot possibly possess the collateral knowledge required to form a correct judgment of all the attending circumstances, and are therefcre extremely liable to fall into error, where every error is attended with risk. Let us suppose, for example, what I have seen and what has often happened, that a timid individual, who has been occasionally subject to palpitation, takes up a medical treatise, and there finds that palpitation is a symptom commonly present where the heart is diseased. It is almost certain that such a person will, in his ignorance, make no farther distinction, but hurry at once to the conclusion that his own heart is affected, and that he must speedily die. This notion being once implanted in his mind, he will become anxious and watchful of every sensation, deny himself necessary exercise from fear of over-exertion, and necessary food from fear of a blood-vessel giving way, and in no long time will fall into a state of weakness and disease which will confirm every one of his apprehensions. But had this man, instead of acting on his own *imperfect* knowledge, consulted his medical adviser, whose business it is to make himself acquainted with the *whole* of the case, he would have discovered immediately that the dreaded source of all this suffering was originally a simple fit of indigestion, which nature would have cured in three days, had not the machine been so perversely deranged by the very want of exercise and food, in which the patient was ignorantly seeking for safety. Even here, be it observed, the danger arises from the *incompleteness* of the knowledge possessed; and I would condemn the perusal of medical books, only because the general reader cannot, except by going through a course of professional study, become qualified to make a proper use of their contents. It is well known that few students escape fits of hypochondriacal apprehension when they first seriously enter on the study of diseases, and that they become free from them almost in proportion as their knowledge advances. It is, then, a most fallacious mode of arguing to contend that, because an imperfect acquaintance with disease is hurtful, knowledge of the conditions and laws of health must also be prejudicial.

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* Maynwaringe on the Method and Means of Health. 1683.

But it is not merely in preserving health, and improving the physical condition of mankind, that physiology is calculated to be eminently useful. As remarked in the first chapter, it applies at least as directly, and with still higher results, to the cultivation of the moral and intellectual nature of man; and it is only by adapting the methods and details of education (using that term in its widest sense), to the principles of a sound physiology, that its full advantages can ever be secured. If man were a disembodied spirit, there might be propriety and safety in overlooking the modifying influence and laws of the material organism; but as Omniscient Wisdom has, for the best of purposes, so constituted us that, during life, the mind cannot exercise its powers except through the medium of bodily organs, by every change in the state of which it is directly affected, surely it is incumbent upon us humbly to conduct ourselves in accordance with this divine arrangement, instead of contemptuously denying its reality, on the false and presumptuous plea, that it would be degradation to the dignity of mind to suppose it subjected, in any way, to the laws which preside over the bodily constitution. If the different powers of thought and feeling were wholly independent of the organism, there would be no relation whatever between their development and that of the bodily frame. But how opposite is the fact! In infancy these powers are unsteady and feeble, simply because the brain is as yet imperfectly developed and organized. In youth, they increase in readiness and vigour; because their material instruments have advanced so far towards maturity. In old age they again become feeble and wavering, from the gradual decay of the organism. In disease they are in like manner exalted or impaired by the excitement or oppression of the brain. Under the influence of wine they are roused to energetic activity, while under that of opium they become buried in sleep. At home and at school, the intellect and feelings are equally dependent on the brain for their power of working; and there, as on every other occasion and at every instant of life, they act always in accordance with the physiological laws of the constitution. It is clear, therefore, that if the teacher remain unacquainted with the connection subsisting between the mind and body, and with the chief circumstances by which the action of the brain is influenced, he cannot with any certainty or precision adapt his methods and his lessons to the constitution of the different mental faculties so as to produce the results at which he aims; and, in many circumstances, it is just as likely that he will do precisely the reverse. This, indeed, too often happens; and I believe there is scarcely a school in the kingdom, in which some part or other of the educational and general training is not at variance with the organic laws, and therefore productive of mischievous results, which might be at once obviated if the teachers possessed even a moderate acquaintance with physiology, and were willing to direct their conduct by its dictates.

In forming a proper estimate of the utility of physiology in the conducting of moral and intellectual as well as physical education, we must never lose sight of the fact that *it is the organism with which mind is connected during life that requires to be exercised and trained*, and by the improved action of which the good effects of education are promoted or realized. In teaching the art of riding, fencing, skating, or dancing, everybody admits at once, that to ensure success regard must be had to the muscular constitution of the individual, and to the laws of muscular exercise. But it is not sufficiently considered that, in cultivating the intellectual and moral faculties, similar regard must be had to the cerebral constitution of the pupil, and to the laws of cerebral exercise. Why does the mind become *weary* after being long intent upon any object of pursuit? Just because the brain, by means of which the mind acts, has become exhausted by over-exercise, in the same way as the muscles do after too long a walk. Why, when the mind is weary of one subject, can it turn to another of a different kind—from mathematics to music, for example—with alacrity and pleasure? Because the organs of the wearied faculties are left in repose; and a different set have come into action which had not previously been engaged; just in the same way as a tailor may be very weary of his day's work, and yet be delighted to enjoy himself at a dance, because in this occupation the weary muscles of the arm are left unemployed, and those of the legs and trunk, which were panting for exercise, now receive it in their turn. To discover, therefore, the proper laws of mental and moral training, we must always have regard to the laws of action of the brain; and as it is the special province of physiology to investigate and expound those laws, it follows that to the educationist, whether parent or teacher, a knowledge of physiology is indispensable to success.

Such accordingly is the case; but as this subject will be considered at greater length when I come to treat of the functions of the brain, it need not be longer dwelt upon at present. Enough, I hope, has been said to satisfy the candid reader that physiology cannot be neglected with impunity by those who either direct or conduct the education of the young.

CHAPTER III.

RELIGIOUS OBJECTIONS TO THE STUDY OF PHYSIOLOGY CONSIDERED.

ALTHOUGH, as we have seen, a deep sense of the usefulness of physiology is rapidly spreading, there is still an influential class of society, which, from a strange misconception of the nature and tendencies of this branch of science, looks upon it with suspicion, and seeks to repel rather than invite its aid. I allude to those who, under a mistaken sense of religious duty, and an erroneous notion of the entire independence of man's spiritual nature in this life, manifest a dread of every truth which implies that the mind is in any degree subject to the influence of the bodily organism; and who, under this ill-founded dread, shew a constant desire to depreciate natural science, which they stigmatise as "merely human knowledge," in opposition to revealed truth, which they consider as alone possessing a just claim to respect and obedience.

The natural consequence of this attempt to set in opposition to each other truths derived from different sources is, that while the precepts drawn from Scripture are urged upon our observance with unremitting earnestness, those derived from the Book of Nature, although written by the hand of the Deity himself, are often practically disparaged, if not actually denounced as unworthy of regard. This is not mere fancy on my part; for when pointing out to such persons the duty and advantage of systematically using the means which God had placed within their reach for the preservation or improvement of their health and usefulness, I have been more than once met with the reply, that such petty observances are altogether selfish, and unworthy of a being destined for immortality; and that the means recommended are mere human devices for the welfare of the body, and as such have no claim upon our reverence or submission, except when rendered necessary by the pressure of actual illness. In a greater or less degree this error is extensively prevalent; and, as its influence is most pernicious, I feel it necessary, at the very outset, to endeavour to remove the mistaken view in which it has obviously originated.

The assumption that science is a mere human invention, necessarily opposed to and incompatible with divine truth, is happily now much less prevalent than formerly, and is so far from being correct that the very reverse may be truly affirmed. In the strictest sense of the word, *science* is nothing else than a systematic exposition of the works and laws of God, discoverable in the field of nature; and if we reflect for a moment, we shall see that it *can* be nothing else. The mere fact, that *man thinks and says so and so*, does not make that exist which has no existence in nature; but, on the other hand, when a law or object has a real existence, man's denial or neglect of it does not in the least diminish the sphere of its action, or lighten the penalty of disregarding it. Thus, an ardent student may believe that excessive study and want of sleep are not hurtful to him; but his false opinion will in no degree prevent their deleterious action. In like manner, a person may believe that sitting inactive with cold wet feet will do him no harm; but such belief will be quite unavailing to protect him against the usual consequences of such behaviour. It is God, and not man, who has created the universe and established the relations which subsist among all its constituent parts, animate and inanimate. Every phenomenon which occurs in the natural world, however striking from its magnitude and extent,—as in the case of an earthquake or a storm, or the movements of the heavenly bodies,—or however incomprehensible from its extreme minuteness, like the microscopic animalculæ, has been devised by His wisdom, and is regulated by His laws. Every truth, therefore, which science demonstrates, and every principle which it unfolds, are traceable to God as their author, and, in common with the inferences rightly deduced from them, demand our respect for this above all other reasons, and carry with them the sanction of the Deity himself. Apart from this, indeed, they would inspire no confidence in their stability, and could present no claim to our obedience. In strictness, it is a pure fallacy to speak of *human* science as contradistinguished from *divine*. Whatever is ascertained to be true in any department of nature, is necessarily divine truth, or, in other words, proceeds from God as its author. One scientific truth may be more or less important to our happiness than another; but all must have the same origin, for harmony and order characterize the whole. It is a matter of notoriety, however, that the sciences are still very imperfect, and that numerous errors are mixed up with their facts and doctrines. If the phrase "human science" were reserved exclusively to designate such errors, we should then be justified in regarding human and divine science as always opposed to each other, and in turning aside from the former with contempt and dislike. But no such reservation has been made. The fundamental facts and laws of most sciences, although first discovered and explained to us by our fellow-men, and not made known to us by any special revelation, are nevertheless as certain, definite, and unchanging, as the fact of man's own existence; and consequently those facts and laws are as universal in their application, and divine in character, as if they had been the subject of a supernatural revelation to man. All truths, from whatever source our knowledge of them is obtained, proceed from God, are necessarily consistent with each other, and have an equal claim on our acceptance, and on our obedience to the commands which they imply. It is indeed one of the highest privileges of science to add to the stock of truths, and to trace the established relations subsisting among them; and one of the greatest pleasures attending its pursuit is the constancy and directness with which every newly discovered fact leads us up to God, as the centre and regulator of creation. Had the facts of science been inaccessible to the scrutiny and reason of man, they would then have been fit objects for a supernatural revelation, seeing that knowledge of them is in so many ways necessary for our guidance to happiness. But, constituted as we are with faculties that delight in observation and in tracing out the relations of all created objects to each other and to ourselves, the revelation of scientific truths without any effort on our part for their discovery, would have deprived man of the noblest field for the exercise of his intellectual powers, and of the strongest stimulus to exertion. As an exposition of the works and laws of God, science has the strongest claim upon the reverent attention of every reflecting and religious mind; because, on our knowledge of these laws, and the squaring of our conduct by them, our welfare, progress, and happiness are in no small degree dependent. Till this grand truth shall be fully understood, and kept constantly before our eyes as a guiding principle, science will never occupy its true position, or confer those advantages on the human race which it is capable of affording. Instead of being opposed to each other, science and religion are identical in nature and origin; and it is a libel on the God of Truth to disparage the facts of science as unworthy of regard, seeing that it is only through them that the laws which He has appointed for the regulation of both the animate and inanimate world can ever become known, or rendered applicable to our farther improvement as physical, moral, religious, and responsible beings.

I have entered at some length into this subject at the outset, because the view which the reader entertains concerning it must exercise no small influence on the spirit in which he will receive the information placed within his reach, and on the willingness with which he will be disposed *to act* upon the rules deducible from it. If he shall regard all scientific truths and inferences merely as ingenious speculations, having no higher origin than the imagination of a fallible human creature, and as carrying with them a merely human sanction, he will naturally think it of little practical importance whether his habitual conduct be directed in accordance with their dictates or not: whereas, if he shall regard the laws of physiology and of all other departments of nature as furnishing plain and unequivocal indications of the divine will, the motives to their study and regular observance will appear no longer a matter of indifference, but a positive duty, ranking among the most important of our moral and religious obligations. Rightly considered, the neglect of health, or its deliberate sacrifice in the pursuit of business, pleasure, or ambition, or even in excessive exertion for the purposes of benevolence, is as clearly a breach of moral duty as suicide itself. The only difference is in degree; and the punishment it entails is frequently of the severest kind—irremediable disease, loss of reason, or death. Proofs and examples of this unfortunately abound in society. For instance, several cases of permanent imbecility from excessive study have come under my own observation, and similar cases are found in almost every asylum for lunatics. The frequency with which naturally strong and well-constituted men are observed to break down from exhaustion in the midst of a prosperous career, furnishes another lamentable confirmation of my doctrine that many fall victims who might have enjoyed a long life of active and useful exertion, had they paid that reasonable regard to the laws of health which common prudence recommends, and which more enlightened views of religion would even have enforced upon them as a sacred duty. It cannot therefore be too deeply impressed upon the public mind that disease and pain are aberrations from the normal condition of the universe. Their prevalence to such an extent as mankind at present endure, forms no necessary part of the plan of creation, but is the result of the neglect of certain laws, which, when observed, maintain the organism in health and strength. Our knowledge is as yet too limited to enable us to understand these laws in all their details, but we cannot on this account deny their existence and efficacy. Every day is adding to our experience, and every day is thus tending to remove the darkness which obscures our full comprehension of them. Even the mystery which shed so much additional horror over the ravages of cholera is being dispelled by the light of recent investigation. "Cholera," says the Registrar-General, "is a health-inspector that speaks in language which nobody can misunderstand: it visits the prisoner in the hulks on the polluted river; the neglected lunatic in his cell; the crowded workhouse; the sides of stagnant sewers; the undrained city; the uncleansed street; the cellars and the attic, as well as the fair open quarters which strangers frequent and admire. The oversights, the errors, the crimes of persons who, in responsible offices, have charge of the health and life of man, are proclaimed aloud by this inexorable voice."* Thus, it is maintained, cholera, like the plague of former times, is the result of man's own ignorance or neglect; and the same assertion might be made of most other ills which afflict humanity.

Influenced by these and similar considerations, and regarding the divine origin of the physiological laws as the feature which gives them their paramount interest and importance, I shall, in the following chapters, constantly endeavour to exhibit the relation subsisting between the rules of conduct which I have occasion to recommend, and the particular laws of the organism from which those rules are deduced, and which give them, when *correctly* deduced, the character of *divine commands*. It is only by clearly understanding this relation, that the reader can fully appreciate the numerous applications of physiological principles to the prevention of suffering and the furtherance of human improvement, and feel the conviction that the recommendations offered for his guidance really rest on the foundation of nature, and are backed by an authority far higher than that of any created being. Hence, while I am too deeply sensible of my own ignorance and fallibility, to claim the slightest deference to any opinion of my own, apart from its accordance with nature, I feel amply justified in demanding the most implicit regard for, and observance of, every rule which can be shewn to have truth for its basis, and the sanction of the Creator for its authority. When a principle or precept rests on doubtful evidence, it would be mere presumption to claim unquestioning obedience to its dictates. But many of the laws of physiology are so fully demonstrated as to leave no room for hesitation on that score. It is quite ascertained, for example, that the lungs and the function of respiration are constituted with reference to breathing a *perfectly pure air*, and that in proportion as the purity of the air we breathe is imperfect, it becomes unfit for the purposes of health and life. God having established this relation as a fact unalterable by us, we are bound, as rational and moral beings, not only to shape our conduct in conformity with it, but to inculcate its close observance upon all over whom we may have any legitimate influence. To this extent we have a divine warrant for our proceedings; because the facts and principles, and the rules deduced from them, are alike universally recognized to be true. The *divine command*, enjoining every human being to breathe pure air, is clear and authentic. But it is otherwise when we proceed, for example, to recommend particular articles of food or clothing in preference to others; because our knowledge of their individual properties and adaptations is still so imperfect, that we have no longer the same absolute certainty to rest upon, and, therefore, are no longer entitled to demand the same implicit assent and obedience as before. All we can do in such circumstances is to state our experience and opinions, and the grounds on which our precepts are founded; and to leave the reader to form his own opinion of their practical value, and to act upon them or not as he sees proper. Nor is this an unimportant service. By substituting rational probability for entire obscurity and neglect, and by honestly avowing our ignorance, we may confer an immediate benefit, and shall certainly prepare the way for an increase of our knowledge, and the safer regulation of our future conduct. I am the more anxious to adhere throughout to the order of nature, both on account of the deep interest inseparable from tracing up every fact and law to its divine origin, and because many of the valuable treatises which have already appeared on the subjects of health and education, have failed to produce an adequate impression on the public mind, chiefly from their doctrines and recommendations having been made to rest on mere opinion or experience, without even an attempt being made to exhibit their relation to the physiological or divine laws, by which alone their fitness or efficiency could be satisfactorily established, their high authority made manifest, and a principle obtained for applying them under every variety of circumstances.*

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* Quarterly Return of the Registrar-General, ending Nov. 30, 1849.—See also an able and earnest pamphlet entitled "The Cholera no Judgment! The Efficacy, Philosophy, and Practical Tendency of the Prayer by the Archbishop of Canterbury, ordered to be used during the Prevalence of Cholera, examined in a Letter to the Right Hon. the Earl of Carlisle." London, 1849.

CHAPTER IV.

STRUCTURE AND FUNCTIONS OF THE SKIN.

In selecting the organs and functions to be treated of in this volume, I have been guided partly by their intrinsic importance with relation to the well-being of the animal economy; and partly by the comparative ignorance which prevails in regard to them, and the extent to which they are under our own control. As characterized by all these features in a very high degree, I shall commence with an explanation of the structure and functions of the skin.

The skin is that membranous covering which is spread over the whole surface of the body, and which serves to bind together, and to protect from injury, the subjacent and more delicate textures. In different animals, and at different parts of the body, it assumes different appearances. It is smooth, soft, and delicate in youth, and in females; firmer and more resisting in middle age and in males; flabby and wrinkled in old age, and after disease; puckered or disposed in folds in places that admit of extensive flexion, as over the finger-joints and in the palm of the hand; and thick and horny where it is subjected to the influence of pressure, as in the soles of the feet.

The structure of the skin, like that of every other part of the animal frame, displays the most striking proofs of the transcendent wisdom and beneficence of the great Creator. Though simple in appearance and in design, it is a compound and elaborate texture, and is the seat of a variety of functions. In a general way, it may be described as composed of two layers of membrane, viz., the thin *scarf-skin* or *cuticle*, and the thick *true skin* or *cutis*, which lies under the other, and directly envelopes the body. In a strictly scientific treatise it would be necessary to enter upon a minute examination of the structure and origin of these constituent parts; but in a work like the present, intended chiefly for the non-professional reader and for practical purposes, it will be more interesting and instructive to confine ourselves to such a general view of the nature and functions of the skin as can be easily understood by every intelligent person, and made available in the ordinary management of ourselves and our families. For this reason, instead of beginning with the consideration of the internal layer or true skin, as a scientific anatomist would do, I shall adopt the plainer method of commencing with the cuticle.

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* For additional observations by Dr Combe on the subject of this chapter, see Letter on the introduction of religion into common schools, in his Life and Correspondence, pp. 501-9. The Letter has been published separately.

Fig. 1.

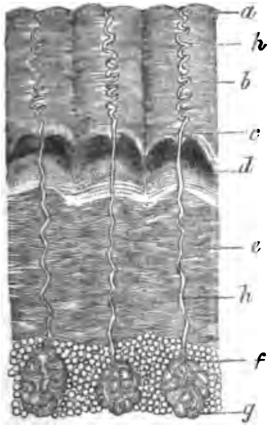

Fig. 1 represents a section of the skin of the palm of the hand, magnified fifteen times, and made transversely to the ridges, three of which it shews.

a b, The external and middle layers of the epidermis.

c, The internal and newly deposited layer, formerly known as the *rete mucosum*.

d, The papillæ, which are here seen associated in pairs, and form parallel rows between which a perspiratory duct passes to open on the summit of the ridge.

e, The cutis or true skin.

f g, The sub-cutaneous fatty layer, in which are imbedded the perspiratory glands.

h h, The perspiratory ducts.

The *cuticle*, *scarf-skin*, or *epidermis* (from ἐπι, upon, and *δερμα*, the skin), is the external layer of the skin, and is that which is raised in blisters. (See fig. 1, *a b*.) To the naked eye, it appears to be a thin continuous membrane, destitute of organization, and without either blood-vessels or nerves. When cut or torn it neither bleeds nor feels pain. It is secreted in a fluid state by the outer surface of the true skin, or rather by a thin glutinous layer covering it, which has received the name of the basement or primary membrane. On this lie, without any definite line of demarcation, a vast number of minute granules or nuclei, which are gradually converted into cells; and these, by aggregation, are in their turn converted into a continuous membrane. Fresh cells being constantly formed, the previous ones are gradually pushed outwards, and slowly lose their moisture as they approach the surface. In this way epidermic strata of different physical properties are formed, and of these, three may, in general, be readily distinguished; namely, the internal, which is moist and soft; the middle, which is still moist, but has become tough; and the third, which is dry and horny. In this last the original polygonal cells have been dried up into thin flattened scales, which friction readily detaches from the surface as a bran-like dust. The cells and scales are so piled one above another that they overlap each other in every direction; and, as they adhere strongly together, they constitute a firm, dense, and almost impermeable membrane, which is so closely applied to the surface of the cutis that it shews exactly the elevations and depressions which exist upon it. Along with the nuclei which are transformed into the epidermic cells, certain coloured granules are secreted, which become incorporated with the cells, and give the skin its darker or lighter hue. They appear of a deeper tinge in the freshly deposited layers of the epidermis, which are yet moist, than in the dry flattened scales of the surface; and are very numerous in the dark races of mankind, especially in the negro, where they are occasionally aggregated in groups so as to form true pigment-cells, similar to those of the eye.

It was long a matter of dispute whether the cuticle be perforated with pores or not. The fact of its giving passage outward to the perspiration, and also inward to substances rubbed upon its external surface, seemed to indicate the affirmative, but many of the older physiologists were induced to question their existence, from the difficulty of accounting for the confinement of the fluid of a blister. It is now, however, fully ascertained that the epidermis is traversed by an infinite number of minute tubes, belonging to two sets of glands, namely those which secrete the perspiration, and those which yield the sebaceous or fatty matter with which the skin is lubricated. With the aid of a magnifying glass, the excretory orifices of the former may readily be recognised on the palm of the hand, as small funnel-shaped depressions on the crests of the ridges; while the openings of the ducts of the latter are well seen on the nose and forehead. The compression which the spiral tubes undergo in the substance of the epidermis from its tense state when raised in blisters, together with the collapse of the ragged ends of the ducts, when stretched and torn by this separation of the cuticle from the cutis, afford a sufficient explanation of the complete retention of the serum.

The structure of the cuticle is thus in admirable harmony with its uses. Placed as an insensible intermedium between external objects and the delicate nervous expansion on the surface of the subjacent true skin, it serves as a physical defence against friction; and while, by impeding evaporation, it preserves the true skin in that soft and moist state which is essential to its utility, it also, by impeding, but not absolutely preventing, absorption, enables man to expose himself without injury to the action of numerous agents, which, but for its protection, would immediately be imbibed, and cause the speedy destruction of health or life. This is remarkably exemplified in several trades, where the workman is unavoidably exposed to an atmosphere loaded with metallic and poisonous vapours, or obliged to handle poisonous substances; and where, without the intervention of the cuticle, the evils to which he is subjected would be aggravated a hundred-fold. The cuticle thus very much resembles a coat of varnish spread over the true skin for its protection, skilfully contrived to allow the free passage outwards of the cutaneous secretions, and to impede the passage inwards of deleterious substances. Being destitute of nerves, it is not hurt by the direct contact of external bodies; and being very thin, it blunts without impairing the distinctness of the impression made on the nerves of sensation. The necessity of this blunting effect becomes very obvious when the cuticle is abraded, or removed by blistering. The surface below is then found to be too tender and irritable for the exercise of touch, and conveys scarcely any other sensation than that of pain.

For the same reason, those parts of the skin which are most exposed to pressure and friction, such as the palms of the hands and soles of the feet, are provided with a thicker cuticle to defend them from injury. The greater thickness of the cuticle in such situations is manifestly the intentional work of the Creator, for it is perceptible even at birth, before use can have exercised any influence. Indeed, were the tender skin not so protected, every violent contraction of the hand upon a rough and hard surface, and every step made on uneven ground, would cause pain, and disable us for exertion.

By another beneficent provision, calculated to afford increased protection according to the necessities of the individual, it happens that, when a part is much used, the cuticle covering it grows thicker and thicker within certain limits, till in extreme cases it grows as thick, hard, and resisting as horn. It is this thickening of the epidermis on the lady's finger that alone enables her to wield with impunity that important instrument the needle.

And it is the same thickening that fits the blacksmith and the mason, the stone-breaker and the boatman, to ply their trades, without that painful blistering which the young apprentice or unaccustomed labourer so regularly undergoes, and which must have continued to recur for ever, had the cuticle been organized with blood-vessels and nerves, or not subjected to this law of becoming thicker wherever increased protection is required.

Another modification of the cuticle to suit peculiar circumstances, is that observed in the nails. These belong to the cuticle, and separate with it; and, like it, they have no visible blood-vessels or nerves, and may be cut or bruised without pain. When the hand or foot is macerated in water, the nails and the cuticle shew their identity of organization, by separating together from the dermis or true skin below. But although insensible themselves, the nails, by conveying the impression of external objects to the numerous nerves which are ramified below their internal surface, constitute one of the most delicate organs of touch, and recognise asperities which escape the feeling of the pulps of the fingers. Like the cuticle they serve also to protect the subjacent parts from injury; and, accordingly, in those lower animals whose manner of life subjects their feet to continual pressure, and requires no nice exercise of touch, Nature has provided horny and resisting hoofs for their protection, instead of merely a thickened epidermis.

But in order to produce thickening of the cuticle, exercise must be gradual, and not too severe. If, for example, a person takes a very long walk, rows a boat, or makes use of a heavy hammer, for a few hours, without having been accustomed to such labour, there is no time for the cuticle to thicken, and strengthen itself for the unusual friction. The parts below, being inadequately protected, become irritated and inflamed, and throw out on their surface a quantity of watery fluid or *serum*, which raises up the cuticle in blisters, and, by making it painful to continue the pressure, obliges the person to desist from an exercise which, if continued, would evidently soon alter the structure of the sentient nervous filaments, and for ever unfit them for their proper uses: So that even in this result, beneficence and wisdom are prominently displayed.

As already stated, the cuticle is remarkable also as being the seat of the colour of the skin. The colouring matter forms, as we have seen, an original constituent part of the epidermis, but, from its being so much more apparent on the inner and moister epidermic surface, many physiologists have been induced to describe the freshly deposited layer of the epidermis as a separate membrane—the so-called *mucous coat* or *rete mucosum.* The deposit of colouring matter varies in different individuals, and in different races. It is more abundant in the brunette than in the blonde, in the negro than in the European. As a general rule, it is increased by the stimulus of light and heat; the complexion becoming dark in summer from its increased secretion, and relapsing into paleness on the approach of winter, when the stimulus of the solar light and heat is withdrawn. In some individuals no colouring matter is deposited; and even in the negro it is occasionally wanting. Such persons are termed Albinos, and are generally remarkable for feeble powers of mind and body. It sometimes happens that the colouring matter is abnormally secreted in greater abundance by one part of the skin than another, and the cuticle is then mottled over with dark sulphur or liver-coloured patches. The cause of this increase depends on some particular condition of the system,—such, for instance, as the state of pregnancy,—and accordingly it is observed that the patches disappear with the peculiar condition which produced them. It has also been remarked, that the browning effects of the sun and air on the human skin are peculiar to a state of health; and Dr Prout thinks he has noticed that individuals with a deep scrofulous taint do not readily become sun-burnt. It is probable, however, that the grounds of this remark lie in the simple fact that persons in feeble health are rarely so much exposed, as the strong and robust, to the solar influence. The dark colour in the negro has been supposed to diminish the heating influence of the sun's rays in tropical climates, from the higher radiating power which is possessed by a black than by a light surface. But there is reason to doubt the soundness of the theory at least; for black is well known to excel in *absorbing* as well as in radiating heat, and the experiments of Dr John Davy and others in Africa and other warm climates seem to shew, that the temperature of the dark-coloured natives does not materially differ from that of Europeans under the same circumstances.

The inmost layer of the epidermis is the seat of the beautiful and variegated colouring observed in the skins of many fishes and other animals, in which it has often a high and almost metallic splendour.

Let us now direct our attention to the *true skin*, *cutis*, or *dermis*, which both in structure and functions is far more important than the cuticle. The cutis (fig. 1, *e*) is a complicated network of fibres interlaced in every direction, possessed of great extensibility and elasticity, so that the skin readily accommodates itself to the shape and varying degrees of protrusion of the subjacent organs. The meshes formed by the interlacing of the fibres are much more compact and dense on the external than on the internal surface of the cutis. On the latter they open up into cells or *areolæ*, which contain the subcutaneous fat (fig. 1, *f*); and some fibres, stretching deeper inwards and forming connections with subjacent organs, serve to bind down the skin, while, at the same time, they allow it a certain degree of motion. The subcutaneous fatty layer varies in thickness in different parts of the body. On the scalp it is about a line in thickness, and, as a general rule, from two to four lines over the rest of the body. Occasionally, however, it forms a stratum an inch thick; but in some parts of the body, such as the hands and feet, where such accumulation would be very inconvenient, no great deposit ever takes place. Its use is to give roundness to the form, and to protect the subjacent delicate structures from injury. The latter of these purposes is beautifully exemplified in the soles of the feet, where the dense fatty layer acts like a cushion and prevents the delicate vessels and nerves from being injured by pressure. The subcutaneous fat is likewise useful in assisting to retain the heat of the body. Partly from its being a bad conductor of caloric, and partly from its serving as a store of heat-producing aliment for the body, it enables corpulent persons to withstand the action of cold longer than spare individuals.*

The true skin, when deprived of the epidermis, appears to the naked eye as a smooth even membrane; but when viewed with a magnifying glass, its surface presents innumerable small elevations, with minute pits or depressions interposed. The elevations (fig. 1, *d*) are the *papillæ* of the skin, the depressions the openings of the ducts of the sebaceous and perspiratory glands.

The papillæ constitute the external organ of touch or feeling, whence the impressions received from outward objects in contact with them are transmitted through the nerves to the brain. They consist of small pyramids (fig. 1, *d*), on an average about $\frac{1}{30}$ of a line in height, but varying in size in different parts of the body. The largest are in the soles of the feet, where a height of from $\frac{1}{22}$ to $\frac{1}{11}$ of a line is attained; while the smallest—in the female cheek—are only $\frac{1}{85}$ of a line in elevation. In some parts of the body, too, they are more numerous than in others; being at certain places so closely set that their bases touch, while at others they are separated by spaces equal to the areas of their bases.

The papillæ contain the peripheral extremities of the cutaneous vessels and nerves. The blood-vessels which supply the skin, give off, in traversing its substance, numerous branches to the sebaceous and perspiratory glands, and on reaching the surface spread out into a fine vascular network, through the meshes of which the papillæ penetrate; the sizes of the apertures which permit their passage being in general regulated by the areas of their bases. Each papilla, according to its size, receives one or more small blood-vessels, which penetrate to the apex, and there bend upon themselves to return to join the vascular expansion. In the same way, every papilla receives at least one nervous twig, and a nervous expansion equal to that of the vascular is formed. The dermis is thus so abundantly supplied with blood and nervous threads, that, for practical purposes, it may almost be regarded as composed of blood-vessels and nerves alone; and it is important to notice this fact. The universal and equal redness of the skin in blushing is itself a proof of great vascularity; but a still stronger consists in our being unable to direct the point of the finest needle into any spot without puncturing a vessel and drawing blood. The same test proves the equal abundance of nervous filaments in the skin: for not a point can be punctured without transfixing a nerve and causing pain; and it is well known that, in surgical operations and accidental wounds, the chief pain is always in the skin, because it is profusely supplied with nerves on purpose to serve as an instrument of sensation.

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* See the author's work on Digestion and Diet, 9th edition, pp. 14, 86.

In addition to its functions of protecting the subjacent parts, and affording a support for the network of vessels and nerves, the skin performs the duties of *a secreting organ*, and as such its importance to the well-being of the organism cannot well be overestimated. For a long time the *perspiration* or sweat was considered to be simply an exudation of the watery portion of the blood from the very minute ramifications of the blood-vessels; and hence the fact of the skin being extremely vascular was supposed to be a perfectly sufficient explanation of the origin and large quantity of the matter thus thrown out of the system. This, however, is a very incorrect view of the subject. The sweat is not a mere watery exudation, but a distinct secretion effected by glands, or small bodies of a glandular nature, expressly provided for the purpose. Each consists of a minute tube, which commences with a blind end in the subcutaneous fatty layer, where it forms a number of convolutions (fig. 1, *f.*) It then passes in a gently waving or spiral line through the cutis, and traverses the epidermis in a compressed spiral course (*h h.*) The number of windings which the duct describes in the epidermis varies with the thickness of this membrane, from one where it is thinnest to about twenty in the heel. The length of the convoluted portion in the fatty layer when unravelled, is estimated by Krause at ¾ of a line, and that of the remainder varies with the thickness of the tissues it has to traverse. The spiral course through the epidermis is probably a mere physical result, dependent on the drying up and consequent condensation of the epidermic layer.

No part of the surface of the body is unprovided with perspiratory glands, but both their number and size vary in different regions. They are largest in the groin and armpit, are most numerous in the palms of the hands and soles of the feet (where, as already observed, their orifices may easily be recognised on the summits of the ridges), and fewest on the back. According to Krause, the extreme numbers are 2736 per square inch on the palms, and 417 on the back.

Supposing the body to present a superficial surface of 15 square feet, French measure, Krause estimates the total number of perspiratory glands to amount approximatively to 2,700,000, exclusive of those of the armpit, which from their comparatively large size he places in a different category; and, including them, he calculates the whole perspiratory apparatus to represent a glandular mass of nearly four cubic inches,* equal in size to about ⅐ of the mass of the kidneys, but having in proportion considerably less secreting power, from their structure being much less compact. But all such estimates must be received more as matters of curiosity than as positive knowledge, and this will be evident on comparing Mr Wilson's calculation of the number of the glands with that of Krause. He estimates them on an average at 2800 in the square inch, and the length of each tube at ¼ of an inch. "Now," says he, "the number of square inches of surface in a man of ordinary height and bulk is 2500; the number of pores, therefore, 7,000,000, and the number of inches of perspiratory tube 1,750,000, that is, 145,833 feet, or 48,600 yards, or nearly twenty-eight miles."* This more than doubles the estimate of Krause, who, however, seems to have been very careful in fixing their number on different parts of the skin, and in drawing an average from the data thus obtained. The conclusions, then, though of little practical value, are still useful in impressing very forcibly on the mind the importance of the exhaling function of the skin.

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* Wagner's Handwörterbuch der Physiologie, vol. ii. p. 131.

From the orifices of the perspiratory ducts the perspiration is constantly escaping as an invisible vapour, which however is made apparent by condensation when the skin, especially that of the hand, is brought into contact with a cold polished surface. When the body is heated by exercise, the action of the glands is so much increased that the air can no longer take up the whole of the secretion as a vapour, and it then appears issuing from every pore as liquid sweat. Viewed as an exhalant, therefore, the skin cannot fail to be regarded with great interest, from the constant influence which it exerts over the welfare of the animal economy. But few have any just notion of the actual extent and importance of the exhalation, such as we shall now attempt to exhibit it.

During the whole period of life, the body is in a state of constant decay and renovation, and when the due balance between these processes is interfered with the health immediately suffers, and fatal consequences often ensue. The skin, the kidneys, the bowels, and the lungs, constitute the channels or outlets by which the waste matter is removed; and the excretion by the skin, though frequently unnoted, is as essential to the well-being of the organism as that through any of the other channels. In the ordinary healthy state of the body, no cutaneous exhalation is *seen*, but the skin is *felt* to be soft and slightly moist. If, however, a cool and well-dried mirror is brought nearly into contact with its surface, moisture is speedily observed to gather upon it, proving that in reality an exhalation of vapour is constantly going on. The same fact is made apparent, as Mr Faraday has recently shewn, by the shadows which vapours may be made to throw, and it is more familiarly proved by the speedy impregnation of flannels or other clothes in contact with the skin, indicated by the peculiar dampness and smell which it imparts to them. Being invisible and impalpable, this, the usual form of exhalation, is called the *insensible perspiration*, to distinguish it from that more copious and fluid secretion which, as we have said, is produced under severe exercise or the influence of great heat, and which, being both visible and tangible, is called *sensible perspiration* or *sweat*.

But physiologists do not in general regard the perspiratory glands as the sole agents concerned in producing the cutaneous exhalation; and Valentin* and Krause† have entered into elaborate calculations to show that the evaporating surface presented by the combined areas of the excretory orifices could furnish only about ⅛ of the quantity of the ordinary insensible perspiration. Hence these physiologists infer that the greater part of this exhalation traverses the skin by the physical process of evaporation, and that the chief use of the perspiratory glands is to secrete the sweat, when by exercise or any other cause the necessity for cutaneous excretion becomes greater than can be satisfied by the insensible perspiration. Krause has shown that although water cannot traverse the epidermis in its liquid form, it readily passes through it in the state of vapour; a fact exemplified in the drying up of the body after death, and the formation of natural mummies in some burial-vaults. Had the structure of the epidermis allowed the free passage of liquids, the surface of the skin would have been constantly cold and moist, or the great evaporation would have dried up the body, to an extent incompatible with the continuance of life.

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* On Healthy Skin, 2d ed. p. 52.

* Lehrbuch der Physiologie, 2d ed., vol. i. p. 619.

† In Wagner's Handwörterbuch der Physiologie, vol. ii., Art. Haut.

The evident importance of the cutaneous exhalation to the welfare of the system at large, has led to many attempts to form an accurate estimate of its amount; but so many difficulties have stood in the way of obtaining precise results, and the difference in different constitutions, and even in the same person at different times, is so great, that we must be satisfied with an approximation to the truth. Among the first inquirers whose accuracy can be in any degree relied on, Sanctorius deserves to be honourably mentioned. With a zeal and perseverance worthy of greater success, he carefully weighed himself, his food, and his excretions, in a balance, every day for thirty years, and came to the conclusion that *five* out of every eight pounds of substances taken into the system pass out of it again by the skin and lungs, leaving only three to pass off by the bowels and kidneys. The celebrated Lavoisier and M. Seguin afterwards entered on the same field of inquiry, and with more satisfactory results, as they were the first to distinguish between the cutaneous and pulmonary exhalations. M. Seguin shut himself up in a bag of glazed taffeta, which was tied over his head and provided with a hole, the edges of which were glued to his lips with a mixture of turpentine and pitch, so that the pulmonary exhalation might be thrown out and the cutaneous alone be retained in the bag. He first weighed himself and the bag in a very nice balance, at the beginning of the experiment; then at the end of it, when he had become lighter in proportion to the quantity of exhalation thrown out by the breathing; and lastly, he weighed himself out of the bag, to ascertain how much weight he had lost in all; and by subtracting the loss occasioned by the lungs, the remainder of course exhibited the amount carried off by the skin. He attended minutely also to the collateral circumstances of diet, temperature, &c.; and allowance being made for these, the results at which he arrived were the following:—

The *largest* quantity of insensible perspiration from the lungs and skin together, amounted to thirty-two grains per minute; three ounces and a quarter per hour; or five pounds per day. Of this, the cutaneous constituted three-fourths, or sixty ounces in twenty-four hours. The *smallest* quantity observed amounted to eleven grains per minute, or one pound eleven and a-half ounces in twenty-four hours, of which the skin furnished about twenty ounces. The *medium* or average amount was eighteen grains a minute, of which eleven were from the skin, making the cutaneous perspiration in twenty-four hours about *thirty-three ounces.** When the extent of surface which the skin presents (calculated at 2500 square inches) is considered, these results do not seem extravagant, while they render it abundantly evident that exhalation must be a very important function of the skin; and although the precise amount varies with circumstances, they make it certain that in health the cutaneous and pulmonary exhalations are frequently more abundant than the united excretions of both bowels and kidneys. According as the weather becomes undertaken by other organs when the action of the skin is checked, and to which is owing the increase of their excretions then observed to take place.

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* These calculations are in old French weight, in which the ounce is about the same as the troy ounce, and the lb. containing 16 oz. is a fourth more than the troy lb. which contains 12 oz.

One of the most obvious illustrations of this reciprocity of action of the various organs is afforded by any convivial company seated in a warm room in a cold evening. The heat of the room, the food and wine, and the excitement of the moment, stimulate the skin, cause an afflux of blood to the surface, and increase in a high degree the flow of the insensible perspiration; which thus, while the heat continues, carries off an undue share of the fluids of the body, and leaves the kidneys comparatively at rest. But the moment the company goes into the cold external air, a sudden reversal of operations takes place; the cold chills the surface, stops the perspiration, and directs the current of the blood towards the internal organs, which presently become excited—and, under this excitation, the kidneys, for example, will in a few minutes secrete as much of their peculiar fluid as they did in as many of the preceding hours. But the *essential and vital* part of the function of an organ cannot so readily be thus transferred, and seldom takes place except in cases of actual disease. We are not therefore surprised to be told by Lehmann, as the result of his numerous experiments, that he found the quantity of solid matter contained in his urine no greater in winter than in summer, although during the latter season its quantity was much less, owing to the increased action of the skin.* The case however is different when the vital action of an organ is disturbed. When this is the case with the skin, disease of some internal organ follows as an unavoidable consequence, and the secretions of the affected organ are altered in quality as well as in quantity. The reverse of this, again, is common in diseases obstructing the secretions of internal organs; for the perspiration then undergoes a change, and is tinged with bile, or acquires a urinary smell, according as the liver or kidneys are affected.

Since the publication of the earlier editions of the present work, the attention of the profession has been strongly directed to the influence of cold in exciting disease in the kidneys as a consequence of suppressed perspiration, especially in persons of an unhealthy constitution. To Dr Bright belongs the honour of having detected the unsuspected frequency and very serious and often fatal nature of the disease alluded to, which is now generally known by the name of *Bright's Disease*, or *Granular degeneration of the kidneys*. In Dr Osborne's excellent little work on the subject, it is expressly stated, that, "*on reviewing the causes of the disease in thirty-six cases, in twenty-two individuals it could be directly referred to suppressed perspiration.*" * Dr Osborne explains this result by saying, that "when cold is applied over the whole surface in a continuous manner for some time, and no inflammation or general fever has resulted, then an increased secretion from the kidneys is usually observed; and the necessity of frequent evacuations of the bladder during the frosts of winter, has become proverbial and is familiar to every one. When the suppression of perspiration, however, instead of being transient, is rendered permanent, then permanent irritation of the kidneys is produced, and, in the great majority of cases, the result is the disease of the kidneys now before us." Dr Christison, in like manner, admits the frequency of cold as the exciting cause, and makes the remarkable statement that, "*where cold was not the apparent cause, I have never met with an instance where the patient could ascribe his illness to any thing else.*" † Dr Prout likewise has called attention to the influence of a cold moist atmosphere in producing renal disease, and he is of opinion that a predisposition to diabetes is often acquired by residing in a damp malarious district. Disordered action of the kidneys, on the other hand, is frequently attended by a dry, harsh, irritable skin, and a tendency to cutaneous eruptions; clearly indicating that the skin and kidneys stand in sympathetic relation to each other, imperfect action of the one impairing the functions of the other.

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* Lehrbuch der Physiologischen Chemie, 2d edition, vol. i., p. 218.

* Osborne on Dropsies, 2d edition, p. 31. London, 1837.

† Christison on Granular Degeneration of the Kidneys, p. 108. Edinburgh, 1840.

The accuracy of the foregoing remarks has been strikingly confirmed by Fourcault's recent experiments on living animals. On coating the shaven skin of dogs with varnish so as to entirely prevent perspiration, he found that the urine became albuminous as soon as symptoms of suffering and difficulty of breathing appeared, and that the kidneys generally resumed their healthy action when the coating of varnish was removed.*

The very frequent occurrence of bronchitis and diarrhœa (the former an inflammatory affection of the lining membrane of the lungs, and the latter of that of the bowels) along with disease of the kidneys, affords an interesting corroboration of what has already been stated in explanation of the sympathy of the excreting organs with each other. In eighteen out of thirty-six cases, Dr Osborne found bronchitis co-existing with the affection of the kidneys, and in eleven some form of intestinal disease. He justly considers, that "the co-existence of these affections with the disease in question is best explained by this circumstance—that *they are all the effect of the one cause, namely, suppressed perspiration.*"

When the lungs are weak, and their lining membrane is habitually relaxed, and secretes an unusual amount of *mucus* or phlegm from its surface, as often happens in persons of an indolent lymphatic constitution, the mass of blood thrown inwards upon the lungs by cold applied to the skin increases that secretion to a high degree. Were this phlegm to accumulate, it would soon fill up the air-cells of the lungs, and cause suffocation; but to obviate such danger, the Creator has so constituted the chest, that accumulated mucus or any foreign body coming in contact with the lungs excites the convulsive effort called coughing, by which a violent and rapid expiration takes place, with a force sufficient to hurry the mucus or other foreign body along with it; just as peas are discharged by boys with much force through short tubes by a sudden effort of blowing. Thus, especially in indolent old Indian officers, and others who have lived long in a warm climate, a check given to perspiration, by diminishing the quantity of blood previously circulating on the surface, naturally leads very often to increased expectoration and cough, or, in other words, to chronic catarrh.

As already noticed, and as we shall afterwards more fully see, the lungs excrete a large proportion of waste materials from the system; and the kidneys, the liver, and the bowels, have in so far a similar office. In consequence of this alliance with the skin, these parts are more intimately connected with each other in healthy and diseased action than with other organs. But it is a general law, that whenever an organ is unusually delicate, it will be more easily affected by any cause of disease than one which is sound: so that, if the nervous system, for example, be weaker than other parts, a chill will be more likely to disturb its health than that of the lungs, which are supposed, in this instance, to be constitutionally stronger; or, if the muscular and fibrous structures be unusually susceptible of disturbance, either from previous illness or from natural predisposition, *they* will be the first to suffer, and rheumatism will ensue; and so on. Hence the utility to the physician of an intimate acquaintance with the previous habits and constitutions of his patients, and the advantage of adapting the remedies to the nature of the cause, when it can be discovered, as well as to the disease itself. Thus, in Bright's disease, which so often proceeds from checked perspiration, Dr Osborne mentions, that whenever he succeeded in restoring perspiration over the whole surface, he never failed to remove the general dropsy by which the affection of the kidneys is accompanied. In like manner, a bowel-complaint may arise from a check to perspiration or from over-eating; but although the thing to be cured is apparently the same, the *means* of cure ought obviously to be different. In the one instance, an emetic or laxative to carry off the offending cause, and in the other a diaphoretic to open the skin, will be the most rational and efficacious remedies. Facts like these expose in a strong light the ignorance and effrontery of the quack, who affirms that his one remedy will cure every form of disease. Were the public not as ignorant as himself, their credulity would cease to afford to his presumption the rich field in which it now revels.

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* Causes Générales des Maladies Chroniques. Paris, 1844.

The close sympathy between the skin and the stomach and bowels has often been observed; and, during epidemic influenza, it is not uncommon for persons of weak digestion to suffer as much from an affection of the stomach as others do from that of the chest. In both instances, there is the same depressing sense of debility and illness without any violent local disease by which it can be accounted for, and in both there is often the same slow recovery. It is well understood, too, that several of the obstinate eruptions which appear on the face and other parts of the surface, owe their origin to disorders of the digestive organs, and are most successfully cured by treatment directed to the internal disease. Even among the lower animals, the sympathy between the two is so marked as to have arrested attention. Thus, in speaking of the horse, Delabere Blaine says: "By a well-known consent of parts between the skin and alimentary canal, ... it follows, in almost every instance, that when one of these becomes affected, the other takes on a sympathetic derangement also, and the condition is then morbid throughout. From close observation and the accumulation of numerous facts, I am disposed to think, that so perfect is this sympathetic consent between these two distant parts or organs, that they change the order of attack as circumstances occur. Thus, when the skin is primarily affected, the stomach becomes secondarily so, and *vice versa;*" so that "a sudden check to the natural or acquired heat of the body, particularly if aggravated by the evaporation of a perspiring state," as often brings on disease of some internal organ, as if the cause were applied directly to the organ itself.*

It is accordingly well known that inaction of the skin is one of the most frequent accompaniments of dyspepsia, and that the restoration of its healthy condition is often the first sure indication of the approaching removal of the digestive derangement. The perspiration, as we shall afterwards see, contains a certain amount of lactic acid, one of the products of the chemical metamorphoses which take place in the organism. But lactic acid is the active acid constituent of the gastric juice, or solvent fluid of the stomach. In excess, however, as has been shewn by Schwann, it impedes solution of the food; consequently, when from inaction of the skin a due amount of lactic acid is not eliminated by the surface of the body, it is secreted in excessive quantity by the mucous membranes, and its presence in the stomach thus gives rise to acidity and disordered digestion. This is the reason why exercise, by increasing the cutaneous excretion of lactic acid, is so signally beneficial in some forms of dyspepsia.

Another consequence of the sympathy and reciprocity of action between the skin and the internal organs is, that burns, and even scalds of no very great extent, prove fatal, by inducing internal inflammation, generally of the intestines. By disordering or disorganizing a large nervous and exhaling surface, an extensive burn causes not only a violent nervous commotion, but a continued partial suspension of an important excretion; and, when death ensues at some distance of time, it is almost always in consequence of inflammation being excited in the bowels or sympathizing organ. So intimate, indeed, is this connection, that some surgeons of great experience, such as the late Baron Dupuytren of the Hôtel Dieu, while they point to internal inflammation as in such cases the general cause of death, doubt if recovery ever takes place when more than one-eighth of the surface of the body is severely burnt. And whether this estimate be correct or not, the facts from which it is drawn clearly demonstrate the importance of the relation subsisting between the skin and the other excreting organs.

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* Blaine's Outlines of the Veterinary Art, 3d edition, p. 65.

Some of Fourcault's experiments bear directly on this point. He found, for instance, that when the cutaneous function was mechanically suppressed by the application of varnish, death followed, in some instances in a few hours, but generally in one, two, or three days, with symptoms which varied according to the nature of the animal experimented upon. In all, the quality of the blood was altered, the secretions from the mucous membranes were increased, and there was effusion of fluid into the serous sacs. Other experiments, in which the skin was taken off, and again applied to the body, support the view that the insensible perspiration is in a great measure simple transudation, as the animals continued not only to live in this condition, but even to be lively, till they were destroyed by the inflammation and suppuration which finally ensued.

In some constitutions, a singular enough sympathy exists between the skin and the bowels. Dr A. T. Thomson, in his work on Materia Medica (p. 42), mentions that he is acquainted with a clergyman who cannot bear the skin to be sponged with vinegar and water, or any diluted acid, without suffering spasm and violent griping of the bowels. The reverse operation of this sympathy is exemplified in the frequent production of nettle-rash and other eruptions on the skin, by shell-fish and other substances taken into the stomach. Dr Thomson tells us, that the late Dr Gregory could not eat the smallest portion of the white of an egg, without experiencing an attack of an eruption like nettle-rash. According to the same author, even strawberries have been known to cause fainting, followed by a petechial efflorescence of the skin.

We have seen that the insensible perspiration removes from the system, without our consciousness, a large quantity of useless materials, and at the same time keeps the skin soft and moist, thus fitting it for the performance of its functions as the organ of an external sense. In addition to these purposes, the Creator has, in his omniscience and foresight, and with that regard to simplicity of means which betokens a profoundness of thought inconceivable to us, superadded another, scarcely less important; namely, *the proper regulation of the bodily heat.* It is well known that, in the polar regions and in the torrid zone, under every variety of circumstances, the human body retains nearly the same temperature, however different may be that of the air by which it is surrounded. This is a property peculiar to life; even vegetables having a power of modifying their own temperature, though in a much more limited degree. Without this power of adaptation, it is obvious that man must have been chained for life to the climate which gave him birth, and even then have suffered constantly from the change of seasons; whereas, by possessing it, he can retain life in a temperature sufficiently cold to freeze mercury, and for a time sustain, unharmed, a heat more than sufficient to boil water, or even to bake meat. Witness the wintering of Parry and Ross and their companions in the Polar Regions; and the experiments of Blagden, Sir Joseph Banks, and others, who remained for many minutes in a room heated to 260°, or about 50° above the temperature of boiling water. The chief agents in this wonderful adaptation of man to his external situation, are undoubtedly the skin and the lungs, in both of which the power is intimately connected with the condition of their respective exhalations. But it is of the skin alone, as an agent in reducing animal heat, that we are at present to speak.

The heat of the human body being about 98°, or at an average 30° or 40° above that of the surrounding atmosphere in temperate climates, it follows that heat must be constantly generated to supply the continual loss occasioned by the contact of the colder air in which we live. The source of this supply lies in the various changes of chemical composition which are incessantly taking place within the body, and the chief external manifestation of which is the absorption of oxygen and disengagement of carbonic acid during the process of respiration. Under ordinary circumstances, and in a temperate atmosphere. no more heat is produced than is readily carried off by the insensible exhalation from the skin and lungs, and by the contact of the colder air. But when the system is excited by active exercise, or by the stimulus of the passions, the development of heat is greatly increased, because with increased action there is likewise increased consumption of material, and the temperature of the body would in consequence soon rise to such a height as seriously to derange the functions were no special provision made for its proper regulation. This is effected by the skin and lungs being excited to higher action; by the latter sending out the respired air loaded with vapour, and the former exhaling its fluid so rapidly as to form sweat. In cold countries, and in frosty weather, the exhalation from the skin is reduced to a very moderate amount, the superabundant heat being rapidly carried off by the cooler air in contact with the body; while in warm climates, where the heat is not rapidly carried off in this way, the surface is constantly bedewed with perspiration, and a corresponding appetite exists for liquids by which the perspiration and evaporation may be kept up to a sufficient degree. Every one must have experienced the grateful effects of this provision, in passing from the dry, restless, and burning heat, like that of fever, to the soft and pleasant coolness which follows the breaking out of the sweat.

Attention to the order of events which occurs when a person is exposed to a warm air, or engaged in severe exercise, affords the requisite knowledge of the means employed for carrying off the heat. At first, the body is felt to be actually warmer, the skin becomes dry and hot, and the unpleasant sensation of heat is soon at its maximum. By-and-by, a slight moisture is perceived on the surface, followed by an immediate increase of comfort. Shortly afterwards, this moisture passes into free and copious perspiration; and if the heat or exertion is still kept up, the sweat becomes profuse and drops from the body or wets the clothes which are in contact with it. A decrease of animal heat unavoidably accompanies this; because, independently of any diminution of vital action contributing to the effect, as is most probable, the mere evaporation of so much fluid is itself sufficient to carry off a large quantity of caloric. The curious experiments of Edwards tend to shew that evaporation is in fact the only means required for reducing animal heat to its proper degree; but the results obtained by him require to be confirmed, and the experiments varied and carried farther, before the inquiry can be considered as complete. The sagacity of Dr Franklin led him to the first discovery of the use of perspiration in reducing the heat of the body, and to point out the analogy between this process and that of the evaporation of water from a rough porous surface, so constantly resorted to in the East and West Indies, and other warm countries, for reducing the temperature of the air in rooms, and of wine and other drinks, much below that of the surrounding atmosphere. The quantity of fluid evaporated from the skin during profuse sweat, so far exceeds that given out during the highest insensible perspiration, that, as already seen on page 32, five pounds in weight have been lost by this means in a single hour—an amount evidently sufficient to carry off the largest quantity of superfluous animal heat which can ever be present. In the performance of this function, the skin is, indeed, assisted by the exhalation from the lungs; but as both act on the same principle, the explanation is not affected by this circumstance.

In the human body the *exhalation from the lungs* is, as a general rule, about half of that from the skin; but in some animals the exhalation from the lungs is probably the greater of the two. Thus, in very warm weather, the dog, even when at perfect rest, is always seen with hurried and panting respiration, and with its tongue protruded from its mouth and copiously covered with froth. As the skin of the dog exhales comparatively little, this hurried breathing is necessary to keep down the temperature by increasing the exhalation from the lungs; and the exposure of the tongue contributes not a little to the same end by presenting a considerable extent of moist evaporating surface.[*]

But the experiments of Fourcault seem to indicate that the skin, besides having the function of *regulating* the heat of the body, is connected also with the process of *developing* it. In repeating these experiments, MM. Breschet and Bequerel expected to find that, when an impermeable coat of varnish was applied to the skin of an animal, its temperature would rise, as superfluous heat would cease to be carried off by evaporation. They were surprised to find that, on the contrary, the temperature of the body fell with great rapidity. As already observed, the animal heat is sustained by the changes of chemical composition which are incessantly taking place in the body, and which cannot cease without the extinction of life. The perspiration, at least in part, is one of the waste products of these transformations of matter, and, consequently, if its escape be prevented, the metamorphoses can no longer proceed; and the source of heat is thus cut off. When the coating of varnish is speedily applied, and is completely impervious, the cause of death seems to be a true asphyxia. The respiration of the animal becomes laboured and difficult; it makes deep inspirations to procure additional oxygen, and death is frequently accompanied by violent convulsions. After death, the lungs and capillary blood-vessels are generally found gorged with dark venous blood, thus presenting appearances similar to those produced by suffocation. M. Fourcault made the curious observation, that when one half of the body is covered with varnish, and the other left in its natural state, the capillary blood-vessels of the skin of the varnished side become distended with dark fluid blood, while those of the other side retain their natural character. Should this remarkable observation be confirmed, an explanation of the phenomenon will probably be found, not in the obstacle which the coat of varnish presents to the oxygenation of the blood of the side from which it excludes the air, but in the impediment, consequent on suppression of the perspiration, to the due performance of the chemical transformations which are essential to the continuance of life. The subject may be illustrated by what occurs in the combustion of inflammable substances. When a free escape is not allowed to the carbonic acid and water which result from the combustion of gas or oil, the process of combustion is impeded or altogether stopped. The two cases are precisely analogous. A free supply of oxygen to the lamp or to the lungs is incapable of supporting combustion on the one hand, or life on the other, unless the products of the chemical changes which occur be allowed to escape. When, however, the transformations are normally performed, the temperature of the body is undoubtedly regulated by evaporation from the surface. It is a matter of daily observation that whatever stimulates the transformations, at the same time increases, within certain limits, the animal heat. Thus exercise, by increasing waste, generates a proportionally increased quantity of caloric. But one of the waste products is water, which, by evaporating from the surface, carries off the superfluous caloric, and thus keeps the body at a uniform temperature.

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[*] In support of these remarks, we may cite the observation of Professor Gurlt, who has shewn that the perspiratory glands of the dog are extremely minute and very difficult of discovery,—whence it is rare to see a dog sweating. Still the action of the skin is here of vital importance, as the animal dies when an impermeable coating of varnish is applied to it. This result gives additional support to the opinion expressed in the text, that the insensible perspiration is to a great extent mere transudation, and that sweat or sensible perspiration is the effect of the action of the perspiratory glands. In the dog, however, these glands are very large in the soles of the feet—exceeding in size those of the palm of the hand in man; and hence Professor Gurlt is of opinion that they secrete in considerable quantity an odorous fluid, by which one dog recognises the traces of another. See Müller's Archiv, 1835.

Bearing in mind the preceding explanation of the functions of the skin, the reader will peruse with interest the following remarks from Dr Thomson's work formerly quoted. "Dr Davy, in his Travels in Ceylon, states, from his personal observation, that on first landing in a tropical climate, the standard heat of the body of a European is raised two or three degrees, and febrile symptoms occur, which require temperance, the avoiding every cause of excitement of the vascular system, and the use of aperient medicines. All authors, and indeed every observing person who has visited the torrid zone, agree that with the languor and exhaustion resulting from the high temperature of the atmosphere, there is a greatly increased mobility of the nervous system. *The action of the cutaneous vessels amounts to disease,* and produces that eczematous or vesicular eruption of the skin, known by the name of prickly heat, which occurs in Europeans who visit the West Indies on their first landing. On the other hand, this function of the skin is so much weakened, almost paralyzed, when the climate from which a person is passing is dry and bracing, and that into which he has passed is humid and relaxing, that congestions of blood take place in the larger vessels, the body becomes susceptible of the least impressions of marshy exhalations, and agues and similar diseases are produced."*

Sir James Clark has shewn that this unsuspected state of congestion often precedes the active appearance of pulmonary and digestive disease, and is in truth the chief cause of the intractability of many apparently slight, but in reality very serious attacks—serious, at least, when their true origin has been overlooked till too late to be remedied. Many so-called severe colds from slight causes owe their whole severity to previously unnoticed congestion, consequent on an unhealthy state of the skin. From this explanation it will be evident why in summer we suffer most from heat in what is called moist close weather, when no air is stirring; and why warm climates that are at the same time moist, are proverbially the most unwholesome. The chief reason is the diminished evaporation from the skin, which such a condition of the atmosphere produces, partially obstructing the natural outlet of the superfluous heat of the body; and as it at the same time checks the exit of the waste matter resulting from the metamorphoses of the tissues, and thereby produces effects most injurious to the system, the hurtful consequences of such weather and climates, and the fevers, dysenteries, and colds, to which they give rise, are partly accounted for.

In the month of June 1846 cholera broke out with great violence at Kurrachee, destroying about a tenth part of the population, including 725 European and native soldiers, in sixteen days. "The climate during the weeks preceding the appearance of the disease among the troops was characterised by several peculiarities different from those which generally belong to all hot countries and seasons, perhaps merely so by their presence being in an excessive degree. First, the temperature was unusually high, being 90° to 92° in the day-time, and 86° at night in good houses, and in the tents of our soldiers it rose to 96°, 98°, and 104°, as indicated by a thermometer suspended on a central pole 5 feet from the ground, and in a thorough draught between the doors. Secondly, the quantity of moisture was greater than I ever saw it before in any part of the world, or at any season, the dew-point being at 83°, and the thermometer in the shade at 90°, the lowest range; even this gives 12·19 grains of vapour in each cubic foot of air."* "In such a condition of the atmosphere," continues the Report, "some of the main excretory functions of the body, particularly the exhalations from the skin and lungs, must be to a great degree suppressed, and a proportionate poisoning of the blood by the retention in the system of matter which ought to be eliminated from it, is inevitable. How much this state of things is aggravated by the absence of wind, and a consequent stagnant condition of the atmosphere, is illustrated by Indian experience, where, from experiment, it appears that from a surface equal to a disc of six inches in diameter, with the dew-point at 83°, and a temperature at 90° in the shade, the evaporation per minute would be equal to half a grain in a calm, 1·40 in a moderate breeze, and 2·10 in a brisk wind; thus making the quantity of fluid removed from the system to be nearly three times as much in a moderate breeze, and upwards of four times so in a fresh wind, as in a calm or stagnant state of the atmosphere."†

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* Thomson's Materia Medica, p. 66.

A moist state of the atmosphere is, moreover, peculiarly unhealthy in marshy districts, by acting as a solvent to the miasma or marsh-poison. In bright clear weather little danger is incurred in traversing unwholesome countries; but towards sunset, when the moisture raised during the heat of the day begins to fall in the shape of dew, laden with the deleterious exhalations of the marshes, the risk of ague becomes considerable. The injurious influence of a moist atmosphere has further been clearly proved by Delaroche by direct experiment. He exposed animals to a very high temperature in a dry air, and found them to sustain no mischief; but when he exposed them in an atmosphere saturated with moisture, to a heat only a few degrees above that of their own bodies, and greatly lower than in the former instance, they very soon died. Here we see also the reason why, in ague and other fevers, the suffering, restlessness, and excitement of the hot stage can never be abated till the sweat begins to flow, after which they rapidly subside; and why the remedies which, when given in the hot stage, only added to the excitement and distress, may now be productive of the best effects.

As a practical, though extreme illustration of the effect of a hot moist atmosphere upon the human frame, it may be instructive to quote the following case, extracted by Mr Wilson from the *Gazette Médicale* of Paris: "A gentleman recently visited the baths of Nero, near Pozzuoli, the ancient Posidianæ. To reach the bath he had to pass along a narrow winding passage of about 120 yards in length, and seven feet high, by about three in breadth. A little within the mouth of the passage, the temperature was 104° in the upper strata of the atmosphere, and 91° near the ground; farther on, the air was filled with a dense vapour, of a temperature of 118° above, and 111° below; and over the bath it was 122°, the heat of the spring being 185°. After proceeding for about one-third the length of the passage, he began to feel a sense of oppression and discomfort, his pulse rising from 70 to 90 beats in the minute. A short distance farther, the oppression increased, his breathing became rapid and panting, and he was under the necessity of stooping his head frequently to the earth, in order to obtain a chestful of air of a less suffocating temperature. His skin at the time was bathed in profuse perspiration, his head throbbing, and his pulse beating 120 in the minute. Continuing his progress, the sensations of suffocation became insupportable; his head felt as though it would burst; his pulse was so rapid as to defy calculation; he was exhausted and nearly unconscious; and it required all his remaining power to enable him to hurry back to the open air. On reaching the mouth of the passage he staggered, and nearly fainted, and was very uncomfortable until relieved by a bleeding from the nose. During the rest of the day his pulse remained at 100; he had uneasy sensations over the surface of the body, and did not recover until after a night's repose. The same gentleman bore a temperature of 176° in dry air without inconvenience."

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* Mr Thom, quoted in Report on Cholera by the Board of Health, p. 27.

† Ibid. p. 29.

By considering the facts above stated, the reader will be prepared to understand why moist climates are more unfavourable to the human constitution than those which are dry. Warm and moist climates are proverbially unhealthy, partly from the greater quantity of moisture which warm air is capable of holding in solution, and partly from the facility which heat affords to the decomposition of decaying vegetable and animal matter. In winter, Holland is comparatively free from fever, but in summer and autumn the inhabitants suffer much from ague, owing to the increase of heat and moisture. Sierra Leone has a most pestilential climate; the temperature is tropical, and the air so damp that ladies preserve their sewing needles in oil to keep them from rusting. Holland, if under the same degree of latitude, would probably be equally unhealthy, and its intermittent fever would become transformed into the black vomit of the African coast, or the plague of Egypt. In the latter country, "during the plague season," says Dr Laidlaw, "the atmosphere is constantly charged with moisture; so much so that the difference between the dry and the wet bulb of the thermometer is not more than two or three degrees, the average throughout the year in Egypt being about eight or ten degrees. I do not know that this applies to Cairo, my observations being made at Alexandria; but I suppose the evaporation is greater at Cairo. The effects of these atmospheric phenomena are so well known to the natives in Egypt, that they express their hopes or their fears according to indications presented to them by the state of the weather. When there is a N.W. breeze with a dry atmosphere, they say, 'if it please God their friends will recover;' but on the contrary, if the wind is S.E., it is considered as markedly fatal."[*] We must not however infer that the sole or essential causes of cholera or plague consist in heat and moisture. They are merely accessory, by predisposing the system to the attacks of those diseases; for, as we shall afterwards see, much more powerful causes are to be found in the exhalations arising from decomposing animal and vegetable matter, and, above all, in the corrupt atmosphere engendered by an overcrowded population.

Besides the perspiratory glands, the skin, as already observed, possesses another series of minute secreting bodies, namely, those which furnish the sebaceous or fatty matter that lubricates the skin. Each sebaceous gland consists of a cluster of small oblong flask-shaped corpuscules, from 1-25th to 1-7th of a line in breadth, and sometimes amounting to twenty in number, grouped round a common duct like grapes round their stalk. They lie imbedded in the substance of the cutis, which they penetrate to about the depth of half a line; but they rarely traverse its whole thickness, so as to reach the subcutaneous fatty layer. The sebaceous product therefore is a true secretion, derived from the blood, and is not an exudation from the subcutaneous fat. The true cutaneous sebaceous glands are always associated with hairs, and their presence on any particular part of the body is at once determined by the appearance of the latter. They are grouped round the hair (*c*, *g*, *d*), in greater or smaller numbers, their ducts opening into the hair-tube (*e*, *f*), and thus supplying the hair with a natural pomatum. The number and size of the glands surrounding each hair are nowise dependent on the size of the latter, and they are frequently largest and most numerous where the hair is fine and downy—as on the forehead, and wings of the nose. In such localities the sebaceous product may frequently be detected, in a sluggish state of the skin, as a minute dark-coloured spot which is the external end of the fine thread of fatty matter retained and moulded into form in the distended sheath of a hair, while the hair itself is frequently so small as to escape notice. The palms of the hands and soles of the feet, being destitute of hairs, have no oil-glands, and we are thus enabled to touch the finest materials without soiling them. To this remark it may be objected that pure perspiration, as shewn by Krause, contains some oily matter; but the quantity is so exceedingly small, as, in this respect, to occasion no inconvenience on the hands. The absence of the sebaceous product on the palmar and plantar surfaces is the cause why the skin in these localities shrivels up on being exposed for a short time to the action of water. This is an appearance never seen on other parts of the body.

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[*] Report on Quarantine by the General Board of Health, p. 8. 1849.

Fig. 2:

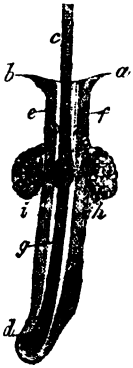

Fig. 2. Represents the lower part of a hair of the fore-arm.
a, *b*, The epidermis.
c, The shaft of the hair.
d, The bulb.
e, *f*, The sheath.
g, The tube.
i, *k*, *h*, Three sebaceous glands which open into the tube.

One use of the fatty secretion, then, is to furnish the hair with a natural pomatum; but its more important purpose is to lessen the hygroscopic properties which the skin, when freed from fat, possesses in a considerable degree. It thus assists in impeding the penetration of liquids inwards through the epidermis, and in preventing the evaporation of the fluids of the body. But it serves also the purpose of protecting the skin against the action of irritants; and hence the glands are both large and numerous in places likely to be exposed to injury from this cause, as in the neighbourhood of the natural apertures of the body.

In the healthy state of the skin the unctuous fluid spreads itself over the epidermis, and is removed by ablution; but when the cutaneous action is sluggish it collects in the ducts of the glands, distends them, and thus produces pimples which are easily removed by pressing out the impacted matter. Attention has recently been called by Simon to the fact that when the sebaceous matter thus accumulates in the glands, small animalcules, termed by him *acari folliculorum*, are generated in it, sometimes singly, and sometimes in great numbers.* They are found in persons of all ages, except new-born infants, and increase remarkably in persons whose vital powers are low. From this fact Mr Wilson infers that they may serve a beneficial purpose in the economy, by stimulating the skin to increased action when the energies of the system are reduced by disease. They are too minute to be recognised by the naked eye, and it requires considerable practice with the microscope to distinguish them in their fatty bed.

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* This discovery had already been made so far back as 1682, but afterwards been forgotten.

Similar animalcules* have been discovered in some of the lower animals, but apparently the parasite which is natural to and innocuous in one animal, may, if transferred to another, occasion serious disease. Thus Professor Gruby inoculated a middle-sized dog with the parasite from man, and in two years the animalcules increased to such an extent as to occupy every follicle of his skin. He lost all his hair, and his skin became as naked as that of an infant. In one particular cavity Professor Gruby counted upwards of 200 animalcules, and he estimated their number, in a surface much less than a square inch, at more than 80,000.*

Having thus concluded our survey of the action of the skin as a secreting organ, let us now direct our attention to the consideration of a contrary function—that of *Absorption.* By means of this function, substances placed in contact with the skin are taken up and carried into the general circulation, either to be appropriated to some new purpose, or to be speedily thrown out of the body.

Absorption is carried on by the blood-vessels, which, as we have seen, are ramified in a close network immediately under the epidermis; and also by another class of vessels called the *absorbents* or *lymphatics*, the distribution of which however is not well known, though fortunate injections shew them to be very abundant on some parts of the skin. Absorption cannot take place till the fluid to be absorbed has passed through the epidermis; it then comes in contact with the walls of the capillary vessels, and penetrates them according to the laws of the physical process of *endosmosis and exosmosis.* In explanation of this process it may be stated, that most liquids, when brought into contact, have a tendency to mix and form one homogeneous whole; and this tendency shews itself in spite of any intervening membrane, provided either or both of the liquids can penetrate its pores. If, for instance, a solution of salt be separated by a sheet of bladder from pure water, the liquids come into contact in the substance of the membrane, because both have the power of penetrating its pores; but the water, being the less dense liquid, penetrates them more readily than the saline solution, and therefore passes through them in greater quantity. Hence it is found that when both fluids have acquired the same composition, the original saline solution has increased in quantity. In the same way, when a fluid after penetrating the epidermis comes in contact with the capillary walls, a reciprocal action commences between it and the contents of the vessels. But a disturbing element, namely that of the *motion* of the contained fluid, here interposes, and the external and internal fluids are prevented from acquiring the same density, by the constant renewal of the contents of the vessels. The internal fluid thus continues more dense than the external, and hence the greater current flows from without inwards—in other words, absorption takes place.*

The action of the absorbents is supposed to be limited chiefly to collecting such part of the debris of the tissues as may still be of use in the organism, and returning it into the circulation. According to this theory, these vessels absorb that portion of the serum of the blood, which, in obedience to the reciprocal action of endosmosis and exosmosis, passes through the walls of the capillary blood-vessels, and is not decomposed in the process of nutrition of the tissues outside those vessels.

In endeavouring to form an estimate of the amount of absorption by the skin, we must bear in mind the structure of the epidermis, which, as already described, consists of an immense number of desiccated cells converted into scales, and overlapping each other in every direction, so as to form on the surface a dry, horny, and transparent membrane. When steeped in water this membrane imbibes moisture and loses its transparency, and the superficial scales become softened and are easily abraded. But the action of the moisture does not extend far beneath the surface; for on the removal of the softened scales the hard and transparent membrane is found unaltered below. Were it otherwise—if fluids could easily permeate the whole thickness of the epidermis—we should be continually exposed to the danger of poisonous matter being thus conveyed into the system. Krause has shewn that liquids which exert no chemical action on the epidermis do not pass through its substance on the principle of endosmosis and exosmosis; and indeed this fact is illustrated in everyday life, for we do not find that the fluid of a blister ever escapes by filtering through the epidermic coat. In this respect the epidermis differs from all other animal membranes; a bladder containing water, for instance, is quite wet on its external surface. It appears, however, that water may penetrate the epidermis in a state of vapour, and this fact is readily proved by covering a vessel containing water with a piece of epidermis. The membrane remains dry, but the water slowly diminishes in quantity. From these facts it seems probable that such substances only as exert a chemical action on the epidermis, thereby destroying its continuity, or such as are volatile and assume the state of vapour, are capable of being absorbed through the substance of the epidermis; although there can be no doubt that, under exceptional circumstances, many bland fluids may be absorbed by penetrating the tubes of the perspiratory and sebaceous glands, where the epidermis is much thinner and more delicate than on the exposed surface of the body.

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* Edin. Monthly Journal of Med. Science, Nov. 1846, p. 283.

* For further details on this subject, see the author's work on Digestion and Diet, 9th ed., p. 29.

It cannot however be denied that possibly the action of water, when long continued, may at length soften the whole thickness of the epidermis, and thus reach the vascular expansion on the surface of the cutis, where it will be absorbed; but Krause regards this process as of very rare occurrence, and believes that when water in its liquid state is absorbed, it must be by penetrating the perspiratory ducts. In the form of vapour, he believes it capable of forcing its way inwards between the cells and scales of the epidermis, precisely as it finds its way outwards in the shape of insensible perspiration; and he thinks that it is as aqueous vapour that the fluid of a blister escapes when the blister dries up. The more volatile a substance, the more easily does it traverse the epidermis; and hence such liquids as turpentine, ether, and chloroform, readily find their way into the blood through this membrane. Accordingly, Dr Aran found the Dutch liquid, or chloride of olefiant gas, to be the best local anæsthetic agent, it being the most volatile substance possessing the power of soothing pain.*

Of the reality of absorption from the surface of the skin, we have a familiar example in the process of vaccination as a protection from smallpox. This process is the insertion of a small quantity of cowpox matter under the cuticle on the surface of the true skin, and the leaving of it there. In a short time it is acted upon, and taken into the system, by the cutaneous vessels. In like manner, mercurial preparations rubbed on the skin for the cure of liver-complaint are absorbed, and affect the constitution precisely as when received into the stomach. Many even of the common laxatives, such as rhubarb and croton oil, may be administered in the same way; and the rapid absorption, through the same channel, of poison from bites of rabid animals and wounds in dissection, is familiar to every one. It is from the active principle of the Spanish flies used in blisters being taken up by the cutaneous vessels, that irritation of the kidneys and urinary organs so often attends the employment of that remedy.

Some ascribe great importance, and others very little, to cutaneous absorption. In certain diseases, such as diabetes, in which, occasionally for weeks in succession, the urinary discharge exceeds, by many ounces daily, the whole quantity of food and drink, without the body losing proportionally in weight, we cannot otherwise account for the system being sustained than by supposing moisture to be extensively absorbed from the air by the skin or lungs, or both. Dr Watson has given the particulars of a remarkable and well-authenticated case of this kind occurring in a boy of eleven years of age, who passed daily nineteen pints of urine, and who gained, in an hour of complete abstinence, one pound in weight, which must have been water derived from the atmosphere.* It is certain, therefore, that the skin possesses an absorbing power in common with the lining membrane of the lungs; and Krause ascribes much more importance to the cutaneous than to the pulmonary absorption, as he thinks the saturation of the breath with moisture in the air-cells of the lungs must materially impede the absorption of moisture from the air. Hence, although the ancients may have gone too far in believing that, when food could not be retained in the stomach, a person might be nourished by placing him in a bath of strong soup or milk, they were, however, correct in principle: their error was in regarding the absorbing power as greater than it really is. Some, indeed, deny that any absorption takes place, because it appears that, as a general fact, the body gains no weight by immersion in a warm bath. But this reason is inconclusive; for, since the body loses at the rate of thirteen grains per minute, if after the bath the weight have not diminished in this proportion, the difference must be owing to absorption. Weight, however, is also occasionally gained: but it is difficult to speak with perfect certainty on this point, because allowance must always be made for a certain quantity of moisture which the cuticle merely *imbibes*. It is well known, for instance, how much more easily corns and callosities, and even the nails, can be cut and pared after being for some time in a hot bath—the softening in such cases being due to the imbibition of a certain quantity of water.

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* Med. Gazette, vol. xlvi., p. 986.

That animals absorb copiously when immersed in water, has been amply proved by Dr Edwards and other physiologists. Dr Edwards selected lizards as the subjects of experiment, because he regarded their scaly skins as unfavourable to absorption. After reducing the bulk of a lizard by several days' exposure to a dry air, he immersed its tail and hind legs in water, and found that absorption took place to such an extent as to restore the original plumpness of *all* parts of the body. The same result attended a variety of other trials, so that the fact does not admit of doubt. In these animals, however, the skin is not protected by an impervious epidermis. Indeed, so permeable is the skin of frogs that the action of the air on its surface oxygenates the blood sufficiently to prolong life for several hours after extirpation of the lungs. In man, the absorption from the surface, which is so much impeded by the epidermis, goes on with great vigour when this obstacle is removed. Thus arsenic applied to cancerous sores, and strong solutions of opium to extensive burns in children, have been absorbed in quantities sufficient to poison the patients. Colic has followed similar external applications of the salts of lead. Mercury, also, in the form of fumigation, has often been used where rapid action was required, because in the state of vapour it is very soon taken up by the cutaneous vessels.

It is quite certain, then, that the skin *does* absorb. The only question is, To what extent does the cuticle operate in preventing or modifying that action? When friction accompanies the external application, the cuticle, as we see exemplified in the use of mercurial and other liniments, is not a perfect obstacle. But when friction is not resorted to, and the substance applied is of a mild unirritating nature, it may remain in contact with the skin for a long time, without being taken into the system in appreciable quantities, though cases undoubtedly occur where unirritating substances, such as narcotics, when applied as simple lotions or as plasters, are absorbed through the epidermis. One of the most familiar examples of this action is the absorption of belladonna when applied to the forehead, as indicated by the dilatation of the iris. Animal poisons are also occasionally absorbed through an uninjured epidermis, and of this Krause gives the following example. After the examination of the body of a man who died of pleurisy, both he and his assistant, he tells us, were attacked with pustules and ulcers in different parts of both hands, and subsequent inflammation of the lymphatic vessels and glands, although the most minute examination failed to discover injury of the epidermis on the hands of either.

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* Medical Gazette, June 1842.

Mr Impey has recorded another remarkable case, in which four persons, who had assisted in examining the body of an elephant, were attacked with pustula maligna. It does not appear whether in this case the ill consequences were attributed to some morbific influence peculiar to the normal fluids of the elephant, as seems to be the popular belief in India, or to some morbid condition of the fluids of this particular elephant. No abrasion of the surface had existed in any of the individuals attacked, who all recovered after an indisposition of from four to five weeks.* The experiments of Mr Ceeley of Aylesbury, on vaccination, afford an additional example of the same phenomenon. He states that he has repeatedly succeeded "in procuring vaccine vesicles without puncture, on the skins of children especially, and young persons, by keeping lymph in contact with the skin, and excluding it from the air by a coating of blood."† In this case, the coating of blood probably aided the absorption by keeping the epidermis in a soft and moist condition. It is difficult to decide whether in such cases the fluids pass through the substance of the cells or scales of the epidermis—or are received into its pores by capillary attraction—or penetrate it by means of some affinity with the contents of the perspiratory or sebaceous tubes: though, where friction is used, as with mercurial ointment, there can be little doubt that the substance is *forced* through the pores, and so comes in contact with a surface no longer protected by an impervious membrane.

It was formerly supposed that when the perspiration is prevented from leaving the surface of the skin either by injudicious clothing or by want of cleanliness, its residual parts are absorbed back into the system, and act upon it as a poison of greater or less power, according to its quantity and degree of concentration, thereby producing fever, inflammation, and even death itself. There can, indeed, be no doubt that animal effluvia act as a most energetic poison; and the skin, we have seen, possesses the power of absorbing them, when in a state of vapour, perhaps with greater facility than even the lungs themselves. Nevertheless, it seems to us more probable that the fatal consequences which have repeatedly followed the use of a close water-proof dress by sportsmen and others, and the heat and uneasy restlessness which ensue in other instances, are not so much owing to absorption of deleterious matter by the skin, as to the circumstance of the water-proof dress acting like the coating of varnish in Fourcault's experiments. It checks more or less completely the exhalations of the skin, and thus cannot but interfere to a hurtful extent with the chemico-vital metamorphoses of the body.

But we concur with those who believe that marsh miasmata and other poisons are absorbed by the skin as well as by the lungs. Bichat considered the fact as established in regard to the effluvia of dissecting-rooms, and many reasons may be advanced for concurring in this belief. Some diseases, for instance, are more readily communicated by contact than by any other means, and this can happen only through the medium of absorption. Besides, it is observed that those who work with oil and other greasy substances which obstruct the pores of the skin, often escape contagion when all around them suffer. In like manner, flannel and warm clothing, which have been proved to be extremely useful in preserving those who are unavoidably exposed to the action of malaria and of epidemic influences, manifestly act chiefly by protecting the skin. A late writer on the Malaria of Rome strongly advocates this opinion, and expresses his conviction that the ancient Romans suffered less from it, chiefly because they were always enveloped in warm woollen dresses. This opinion, he says, is justified by the observation, that since the period at which the use of woollen clothing came again into vogue, intermittent fevers have very sensibly diminished in Rome. Even in the warmest weather, the shepherds are now clothed in sheep-skins. Brocchi, who experimented extensively on the subject, obtained a quantity of putrid matter from the unwholesome air, and came to the conclusion, that it penetrates by the pores of the skin rather than by the lungs. He ascribes the immunity of the sheep and cattle, which pasture night and day in the Campagna, to the protection afforded them by their wool and hair ;* and Spalding says of malaria, that the best preservatives are shelter by night, and warm thick clothing by day (like that of the friars, who live while the peasants die in troops around them), and an avoidance of sudden change of temperature.† These remarks deserve serious attention—particularly as, according to Patissier, similar means have been found effectual in protecting the health of labourers digging and excavating drains and canals in marshy grounds, where, previously to the employment of these precautions, the mortality from fever was very considerable.

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* Trans. of the Med. and Phys. Society of Bombay, No. VIII.; quoted in the Medical Gazette, May 25, 1849, p. 910.

† Wilson on the Skin, 2d edition, p. 64.

The foregoing observations are quite in accordance with the doctrine previously delivered, that the epidermis, though nearly impervious to liquids which exert no chemical action on the skin, is readily penetrated by vapour. The protection afforded by warm clothing is probably explicable, at least to a partial extent, by its preventing the immediate contact of the skin with the malaria. We have the records of many experiments which prove that gases are readily absorbed by the skin, and need only adduce as an example one performed by Collard de Martigny, who placed himself in a cask containing the husks of grapes in a state of fermentation, but where, by means of a tube, he was provided with a due supply of air for respiration. At the end of 29 minutes he had become, through absorption of carbonic acid, almost senseless. Some interesting experiments have recently been made by M. Renault, director of the veterinary school of Alfort, with the view of elucidating the time necessary for the absorption of an animal poison by the skin, and its communication to the system at large. His experiments were made on horses with the poison of glanders, and on sheep with the poison of rot. The virus was introduced under the cuticle with a lancet; and at certain periods after inoculation the puncture was cauterized so as completely to destroy the poison, if it had not already been carried into the system. Thirteen horses were thus experimented upon, and the cautery was applied at periods varying from 96 hours to 1 hour after inoculation. None of the animals escaped the effects of the poison. Twenty-two sheep also were inoculated, and the cautery was applied at periods gradually diminishing from 11 hours to 5 minutes after insertion of the poison; but here likewise none of the animals escaped. It is thus proved that the contact of a virus, during a period of one hour for glanders, and five minutes for rot, is quite sufficient to inoculate the system with the poison. It is probable indeed that a shorter period may suffice; but whether this be the case or not, these experiments shew that no time ought to be lost in removing the poison of a wound by suction, or in destroying it by the application of the cautery. The consequences which are apt to ensue from wounds accidentally received in dissecting, or from the bites of rabid animals, can only thus be effectually guarded against. The facts just mentioned also place in a striking light the danger of exposure to malaria even for the shortest period.

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* Edin. Philos. Jour., Jan. 1838.

† Italy and the Italians, vol. iii., p. 299.

It is a general law, that every organ acts with increased energy when excited by its own stimulus; and the application of this law to the different functions of the skin may help to remove some of our difficulties. The skin exhales most in a warm dry atmosphere; because heat is its stimulus, and dryness of the air is favourable to the evaporation of the sweat. The same condition is unfavourable to absorption, because no moisture is present to give the absorbing vessels of the skin occasion to act. In a moist atmosphere, on the other hand, they meet with their appropriate stimulus, and act powerfully; while exhalation is greatly diminished, because the air can no longer carry off the perspiration so freely. It is partly on account of diminished exhalation from the skin, partly because a moist atmosphere lowers the tone of the system, by carrying off the animal heat much more rapidly than one which is dry, and partly also perhaps from the increased action of the absorbent vessels which always accompanies moisture, that the lymphatic system predominates among the inhabitants of marshy and humid districts, as has long been remarked of the Dutch. Malaria prevails chiefly in situations and seasons in which the air is loaded with moisture, and it is most dangerous when the power of resistance is least, as during sleep or fasting. At such times the probability of its being received into the system by cutaneous absorption is unusually great, and the consequent necessity of endeavouring to protect ourselves from its influence by warm woollen clothing becomes most urgent. When the skin is warm and its exhalations are abundant, the body is surrounded by a vapory layer of perspiration which shields it against the contact of malaria; and no reciprocal action between the fluids of the body and the moisture of the air can take place, either on the surface of the skin or in the perspiratory ducts, because the constant flow of the perspiration prevents the air from resting on the surface, or penetrating into the ducts. But when a chill or any other depressing cause has checked the flow of the cutaneous exhalations, the air is allowed to rest in contact with the skin, and miasmata are then peculiarly apt to be absorbed and to produce disease. In the army and navy, accordingly, where practical experience is most followed, the utmost attention is now paid to enforcing the use of flannel and sufficient clothing as a protection against fever, dysentery, and other diseases, particularly in unhealthy climates. In the prevention of cholera, flannel was decidedly useful.*

From grouping all the constituent parts of the skin into one whole, and perceiving so many operations connected with that tegument, some may be apt to suppose it an exception to the principle, that no single part can execute more than one special function. In reality, however, it is only by taking the guidance of this principle that we can extricate ourselves from the apparent confusion. We have already seen that exhalation and absorption are connected with the vascular tissues of the skin, and on further examination we shall now find the office of Touch or Feeling intrusted exclusively to another constituent part, *the nervous;* for, in serving as the instrument of Sensation, the skin acts in no other way than by affording a suitable surface for the distribution and protection of the nerves which receive and transmit to the brain and mind the impressions made on them by external bodies. In this respect the skin resembles the other organs of sense, in all of which *the nerve is the true instrument of the sense.* The eye, the ear, the nose, and the skin, are simply structures fitted to bring the nerve into relation with light, sound, smell, and external bodies, by which these organs are respectively affected:—and they differ from each other only because sound differs from colour, colour from smell, and smell from roughness or smoothness; and because sound or colour can be taken cognizance of by its own nerve, only when the latter is provided with an apparatus fit to be acted upon by the vibrations of the air, or by the rays of light. In every instance, it is *the external object acting upon a nerve* which gives rise to the impression received from the organs of sense.

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* In Dr Madden's work on Cutaneous Absorption, Mr Wilson's on the Management of the Skin, and also in two excellent articles on the Skin in Nos. IV. and XII. of the British and Foreign Medical Review, the reader will find additional information concerning the structure and functions of the skin, and especialy, on the subject of its absorbing power.

The skin being the seat, and the nerve the immediate instrument, of sensation or sensibility, it becomes an object of interest to ascertain in what manner the nerve is so distributed over the skin, as to enable it to come into contact with external bodies without the risk of sustaining injury from their roughness or hardness.

We have already seen, in a general way, that this is done by the papillæ (fig. 1, *d*, page 25), which in their simplest form consist of loops of a single nerve and artery, doubled upon themselves, and covered by an investing membrane. But in situations where increased sensibility is required, the papillæ are larger, and are composed of a number of nervous and arterial branches, bound up together, and forming small cones. The bases of these cones rest on the dermis, and their apices penetrate into the epidermis like a sword into its sheath, so that the depressions on the internal surface of the epidermis represent exactly the number and disposition of the papillæ. By this arrangement, the tactile extremity of the nerve which enters into the papilla, is allowed to come into more direct contact with the external objects which it is intended to recognise, and thus to appreciate them more correctly. Touch is exercised by thousands of these little organs, all placed side by side, as it were, and communicating together by means of the nervous network spread over the whole surface of the body from one papilla to another; and the proof that the nerve really penetrates into the papilla is, that although the epidermis may be removed with impunity, acute pain is felt the moment the papilla itself is injured. Even the mere contact of the air causes pain when the protecting epidermis is removed.

The papillæ are dependent for their life and action on a constant supply of blood. When the surface of the body is warm, and its circulation active, touch and sensation are acute, because the nerves then receive abundance of stimulating blood. But when the skin is chilled, and its circulation nearly stagnant, sensation becomes so blunt that wounds may be inflicted without exciting pain; because then the nervous papillæ, being imperfectly supplied with blood, can no longer act with readiness or vigour. The cutaneous nervous expansion thus constitutes one of the most important tissues of the body. It forms the peripheral extremity of the nervous system, on which external agents act,—through which the mind is made cognizant of external objects in contact with the skin, and thus far is put in relation with the external world. If the sensibility of the skin were destroyed, man would be comparatively helpless. He could feel neither heat nor cold; he could not walk, for he could not tell, except by the eye, when his feet touched the ground; he could not write, for he would not know that his fingers held the pen. An ass, in which the nerve that bestows sensation on the lips was cut, left its oats untasted, because it no longer felt the wonted impression, and did not know when its lips came in contact with the food.

Such being a chief purpose of the skin, it follows that every part of it, however remote, must be provided with filaments from the nerves of sensation, that we may become immediately sensible of the presence and action of external bodies. If any part were destitute of this property, its texture and vitality might be destroyed without our being conscious of the fact; whereas, in consequence of this provision of sensitive nerves, no object can touch the skin without our being instantly made aware of its presence and properties. A case published by Dr Yellowly, in the third volume of the *Medico-Chirurgical Transactions*, illustrates in a striking manner the great utility of these nerves in warning us of danger. He says: "The patient's hands up to the wrists, and the feet half way up the legs, are perfectly insensible to any species of injury, as cutting, pinching, scratching, or burning. He accidentally put one of his feet, some time ago, into boiling water, but was no otherwise aware of the high temperature than by finding the whole surface a complete blister on removing it."

While, however, sensation is common to the whole surface of the body, there are parts of the skin more peculiarly destined by Nature for the exercise of Touch, and for the appreciation of all the qualities of which it is cognizant. Such are the hands and tongue in man, the proboscis in the elephant, the tail in some of the monkey tribes, and the tentacula in fishes. This was shewn experimentally by Weber, who found that the points of a pair of compasses required to be separated only half a line to produce two impressions on the tongue, while a separation of one line was necessary for the tips of the fingers, of ten lines for the skin of the forehead, and of thirty for that of the middle of the arm.* Now, in accordance with the explanation given of the dependence of sensation upon nervous endowment, it is remarkable that all the parts destined for this special exercise of Touch, receive the most abundant supply of sensitive nerves. Thus, the nerves going to the hand and arm, the most perfect instruments of this sense in man, have their dorsal or sentient roots five times larger than those which are destined to produce motion; and, in like manner, the nerve supplying the tactile extremity of the proboscis of the elephant, exceeds in size the united volume of all its muscular nerves. On the other hand, in animals covered with hair or feathers, whose sense of Feeling is comparatively defective, the muscular nerves far exceed in size those of sensation; and wherever Nature has endowed any particular part with acute sensibility, she is invariably found to have distributed to that part, and to it alone, a proportionally high nervous endowment. In man the papillæ vary in size in different parts of the body. They are largest and most numerous on the tongue, the fingers, the palm of the hand, and sole of the foot, where sensation is most acute; and they may be distinctly seen on the hand, running in irregular ridges, each ridge containing two parallel rows of papillæ, between which are the ducts of the perspiratory glands (fig. 1, *d*.) On the skin of the scalp, on the other hand, they are so small and wide apart that Professor Gurlt had difficulty in detecting them. In fishes, no nervous papillæ can be discovered on the surface of the skin; but many of them have tentacula or projections generally about the mouth, for the special purpose of exercising Touch, and these are always plentifully supplied with branches from the fifth pair of nerves.

The nervous tissue of the skin is thus not only an important instrument for receiving and conveying to the mind accurate impressions in regard to the properties of external objects, but it is even essential to our continued existence. The pain which is caused by injuries is no doubt very disagreeable; but in its uses it is a positive blessing, by warning us against the danger, and even certain destruction, which would speedily overtake us if we had no such monitor at hand. If there were no nerves on the surface to communicate to us a lively impression of cold, we might inadvertently remain inactive in a temperature which would not only suspend perspiration, but benumb the powers of life; or we might approach so near the fire or boiling fluids, as to destroy the organization, without being conscious of the fact. Whereas, through the kind interposition of the nerves, we cannot, when perspiring freely, be exposed to the cold air, without experiencing an unpleasant sensation, which impels us to attend to our safety, and to keep up our heat either by additional clothing or by active exercise. When both the nervous and the vascular parts of the skin are in healthy action, there is felt over the body a pleasant warmth, which is generally accompanied by an agreeable consciousness of active existence, the very opposite of the low and languid depression so often attendant upon continued defective action in the skin.

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* Müller's Archiv, 1835, p. 152.

For the due exercise of Sensation, the nerves must be in a proper state of health. If, for example, the cuticle protecting the nervous papillæ be abraded, or removed by vesication, the naked nerves will be too powerfully stimulated by the contact of external bodies, and, instead of receiving and transmitting the usual impressions of heat, cold, hardness, &c., they will communicate scarcely any feeling except that of pain. If, on the other hand, the cuticle become thickened by hard labour, the impression made on the nerves will be proportionally lessened, and little information be conveyed by them to the mind.

I have already remarked that a due supply of arterial blood is another requisite for the action of the nerves of sensation, and that if they be deprived of this (as by exposing the body to a degree of cold sufficient to drive the blood from the surface), the nerves will become almost insensible, and severe wounds may be received without the individual being conscious of the accident, or feeling the slightest pain. For the same reason, severe cold ceases after a certain time to be painful, and death ensues like deep sleep and without suffering. But when a frozen limb is thawed, and the returning circulation begins to set the nerves in action, suffering forthwith commences, and there is much risk that inflammation will arise from the over-action. The same phenomena, in an inferior degree, must be familiar to every one, in the tingling so commonly complained of on heating cold hands or feet too rapidly at a good fire—a symptom produced by the return of the blood stimulating the nerves to undue action. The benumbing effects of cold have recently been turned to practical account by Dr James Arnott of Brighton in performing some of the minor operations of surgery.* A pig's bladder containing water is placed over the intended site of the operation, and ice and afterwards salt are gradually added, so that the temperature may be slowly reduced, in order to guard against subsequent reaction. Fifteen or twenty minutes are generally sufficient to produce an amount of insensibility capable of allowing a square inch of skin to be dissected off, or a seton to be passed, without producing pain; but future experience must shew if this procedure can be adopted without fear of subsequent inflammation from vascular reaction.

It is the nervous tissue of the skin which takes cognizance of the temperature of surrounding bodies, and imparts to us the sensations of warmth and coldness. In the present state of our physiological knowledge, we cannot distinguish any difference in the physical properties of the sensitive nerves which supply the skin, and those which confer sensation on the muscles and other internal structures of the body. But the experiments of Weber shew that some difference must exist; as only the nerves of touch—that is, those of the skin and mouth—

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* Lancet, July 22, 1848.

are capable of recognising heat and cold. When plates of metal, heated to different degrees, were applied to a part of the surface of the body where the skin had been disorganized by burns and its restoration was still incomplete, he found that the subject of the experiment could not tell whether the metal was hot or cold, although he was conscious of *pain* when its temperature somewhat exceeded 120° F.* It is probable that this difference of the power of sensation arises from some modification which the peripheral extremities of the cutaneous nerves undergo in the papillæ.

In the healthy state, the sensation is a correct index of the real temperature; but in disease, we often complain of cold and shivering when the skin is positively warmer than natural. In this way, people whose digestion and circulation are feeble complain habitually of cold, and of cold feet, where others experience no such sensations. Exercise dissipates this feeling by exciting the functions of respiration and circulation, propelling the blood to the surface, and thereby increasing the action of the cutaneous vessels and nerves.

Some mental emotions affect the skin and its functions much in the same way as cold. Thus grief, fear, and other depressing passions, diminish respiration and the afflux of arterial blood, and consequently render the skin pale, check perspiration, and impair nervous action; while rage and other violent passions, by augmenting respiration and the afflux of blood, elevate the temperature of the surface, and give rise to the red flush, fulness, and tension, so characteristic of excitement. Sometimes, indeed, the effect of mental emotions on the skin is so great as to induce disease. In speaking of impetigo, Dr Bateman mentions two gentlemen in whom the eruption arose from "great alarm and agitation of mind;" and adds, that he "witnessed some time ago the extraordinary influence of mental alarm on the cutaneous circulation, in a poor woman who became a patient of the Public Dispensary. A sudden universal anasarca (dropsy under the skin) followed, *in one night*, the shock occasioned by the loss of a small sum of money, which was all she possessed."* Facts like these establish a connection between the brain and the skin, which it is important not to overlook.

The reverse influence which the condition of the nervous matter distributed over the surface of the body exerts on the rest of the system is also well known, and is exemplified in the effects of exposure to intense cold. The first sensation of chill excited in the nerves of the skin is quickly succeeded by that of numbness and insensibility; and if the exposure is continued, the impression is speedily communicated to the brain, and confusion of mind, followed ultimately by death, comes on. When, on the other hand, as in tropical climates, the surface is relaxed by excessive heat, the brain speedily participates in the relaxation, and the mind becomes unfit for sustained or vigorous action.

Invalids and literary men often suffer severely from excess of action in the brain, and deficiency of action in the nerves of the skin and remoter organs. The nervous stimulus and action which are essential to digestion and to the health and warmth of the skin, cannot be kept up when the brain is too exclusively exercised in thinking or feeling; and from want of a sufficiency of this stimulus the tone of the digestive and cutaneous organs is greatly reduced; the surface of the body becomes cold, shrunk, and uncomfortable, and the individual is subject to annoyance and painful sensations from trifles which formerly gave pleasure. Bad digestion and deficient warmth of surface are thus proverbially complained of among literary and sedentary persons, and cannot be removed without exciting the nervous and vascular functions of the skin, and diminishing those of the brain.

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* Müller's Archiv, 1849, p. 273.

* Bateman on Cutaneous Diseases, p. 150.

Before terminating our description of the skin, it is proper to add a few words on its ornamental appendage, the hair. In fig. 2, page 43, the hair, *c*, is seen originating in a bulbous swelling, *d*, at the bottom of a follicle deeply implanted in the skin, *a b e f*, and frequently penetrating a considerable way into the adipose tissue beneath. It receives additions to its substance by the bulb, and is slowly pushed upwards as the fresh deposit is made at its base. Before reaching the surface it is lubricated by the secretions of the oil-glands, *h i k*, which, as we have already seen, do not constitute an independent apparatus, but are always associated with the hair. The size of the glands bears no constant relation to that of the hair; they are often largely developed in association with the finest down, as on the nose and female lip. In enfeebled states of the system the hair is apt to become dry and harsh from deficiency of the oily secretion, and not unfrequently falls out from imperfect nutrition after fevers and other severe maladies. In advanced life the hair of the scalp is often lost from atrophy of the hair-tubes, while, on the contrary, the fine downy hairs occasionally acquire increased development, as in the beard and mustaches which sometimes make their unwelcome appearance on the female face. It is a curious fact that baldness of the scalp is much more frequent in men than in women; one cause of which, probably, is the use of waterproof hats, which impede the exhalations from the skin, and so derange the nutrition of the hair. The use of caps, again, may produce the same effect by causing relaxation and atrophy of the hair-tubes. It is at all events remarkable that the hair is generally persistent on those parts of the scalp which the head-dress does not cover, and this even when the rest of the head is perfectly bald.

CHAPTER V.

CONDITIONS OF HEALTH OF THE SKIN, AND ITS INFLUENCE ON THE GENERAL SYSTEM.

From the foregoing exposition of the structure and functions of the skin, the principles on which its physiological management should be conducted will be sufficiently apparent. But as knowledge becomes valuable only in proportion as it is rendered subservient to the improvement and happiness of man, I shall offer no apology for now directing the attention of the reader to some of the advantages which may be derived from the practical application of the information which has just been communicated.

Taking the natural constitution of the skin for our guide, we must infer that the conditions essential to its healthy action are, *first*, that a free and equal circulation of blood shall take place over every part of its surface; *secondly*, that a free and equal perspiration shall be kept up in every part, in due relation to the circumstances in which the individual is placed; *thirdly*, that the *residuum*, or remains, of the perspired matter, and all external impurities accidentally deposited on the surface of the body, shall be scrupulously and timeously removed; and, *lastly*, that the contact of noxious substances likely to be absorbed by the skin should be carefully avoided and removed.

As the means which are most effectual in ensuring a free and equal circulation of blood over the whole surface of the skin, are at the same time more or less directly efficacious in keeping up a due degree of perspiration, and in removing impurities from the surface, I shall, to avoid unnecessary repetition, treat of them together, in relation to all these purposes. Those among them which chiefly require our attention, are bodily exercise, suitable clothing, friction, and bathing.

The temperature of the surface is a pretty good test of the state of the cutaneous circulation and perspiration.

When the skin is comfortably warm, its depth of colour, pleasant softness, and moisture, indicate that the blood circulates freely through its minuter vessels, and that the perspiration is healthy and active. When, on the other hand, the surface is chilled and pale, we may be sure that its circulation is inactive, and perspiration deficient. Hence, the proper regulation of its temperature is, in one sense, the first requisite to the preservation of its health; because when this is effected, it is almost infallibly certain that all the other cutaneous functions are adequately performed.

The influence of bodily inactivity in impairing free action of the skin and causing a sensation of chill, is both striking and easily explained. Animal heat proceeds from the combination (or, as it may be termed, the burning) of the carbon and hydrogen of the blood with the oxygen of the air inhaled during respiration; just as heat is generated during the more rapid combustion of carbon in the open air. When the combustion goes on actively, much heat is of course generated, and the body becomes warm. When it goes on slowly, little heat is produced, and consequently a sensation of chill is felt. But in the animal system, as well as in the physical world, the activity of the combustion* depends, first, on the supply of fuel, and, secondly, on that of pure air. When these are at their maximum, heat is generated most rapidly. Now, speaking in a general sense, the food constitutes the fuel necessary for the production of animal heat, and which, after being converted into blood, is carried to all parts of the body; while the air inhaled in breathing is the source from which the oxygen necessary for the combustion is supplied. Consequently, whatever gives keenness to the appetite, and produces free and deep respiration, and stimulates the circulation of the blood, furnishes all the conditions necessary for the rapid generation of animal heat. Mental excitement, and bodily exercise in a pure bracing atmosphere, are precisely the circumstances which produce the effects required; and hence their well-known influence in promoting warmth, health, and comfort. On the contrary, whatever impairs the appetite, obstructs the circulation, or weakens respiration, tends in an equal degree to lower the heat-producing power. For example, all these effects follow indulgence in mental sloth and bodily inactivity, and breathing an impure air; and hence the chill and impaired digestion which are so commonly the accompaniments of sedentary habits. Inadequate clothing acts somewhat in the same manner. The heat-producing power of the body being limited, protection by clothing is required to prevent the too rapid dissipation of the caloric in a cold atmosphere; and consequently the warmest clothing is always required when the calorific power is most feeble. This is the reason why active well-fed men, living much in the open air, are capable of sustaining uninjured, though without any unusual covering, a degree of cold almost sufficient to destroy an ill-fed and sedentary artisan, living habitually in a vitiated atmosphere.

From the foregoing general explanation of the sources of animal heat, and their close dependence on the amount of exercise and nourishment, and the purity of the respired air, the reader will easily understand the important bearing which the same conditions have on the healthy action of the skin, and will perceive why a person with impaired digestion, or insufficiently supplied with food and exercise, should suffer habitually from a dry chilly skin and cold feet; and why a genial glow and soft skin should be enjoyed, when the mode of life is such as to fulfil the conditions under which only they can occur. Into this subject, however, I need not enter at present, as in a subsequent chapter I shall have occasion to treat very fully of exercise and its effects on the general health. It is enough in the mean time to have indicated that regular bodily activity is as necessary for the proper performance of the functions of the skin, as for the due action of all other parts of our organism.

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* The term *combustion* does not here imply the direct combination of the oxygen of the air with the hydrogen and carbon of the blood to form water and carbonic acid. Before this last step is arrived at, a long series of intermediate compounds are formed, which are classed under the somewhat vague title of *the products of the chemico-vital transformations* of the organism.

As man lives in an atmosphere generally many degrees colder than his own body, the means of preventing his being cooled down too rapidly are forcibly pressed on his attention; and as the skin is the most exposed part, these means must apply chiefly to its protection. Hence the necessity for clothing, especially in temperate and cold climates; and hence the influence of *unsuitable or inadequate clothing* in impairing, and of *suitable clothing* in protecting and restoring, the functions of the skin, at all ages, in all ranks of society, and in all seasons. In infancy, and especially among the poor, want of proper clothing, and the consequent exposure to cold, are frequent causes of death, and still more frequent causes of sickness. From the *Reports of the Registrar-General of Births, Deaths, and Marriages in England* for 1838–9, confirmed by the subsequent returns, it appears that one-third of all the deaths registered, or 343 per 1000, occur under three years of age. On inquiry, it is found that the proportion of such deaths among the poor is far greater than among the middle and richer classes. A very influential, although by no means the only, cause of this excess among the poor, is the inadequate protection afforded to the new-born infant against the effects of the sudden transition which it makes in passing from a high and almost unvarying temperature in the mother's womb, to one greatly inferior and constantly liable to change. But this physical difference is of small consequence when compared with that which ensues in the vital actions of the body. Hitherto the temperature of the infant has been supported by the chemico-vital metamorphoses of the mother, but now it is suddenly called upon to generate its own heat. For this purpose a new set of vital actions, of which respiration is the chief, is immediately called into play. At first, however, the powers of life are feeble, and few animals, as has been shewn by Dr Edwards, are capable at birth of sustaining their temperature unaided. The skin, from prolonged contact with a warm medium, is then extremely delicate and vascular, and highly susceptible of impressions—so much so, that cases have occurred in which a leech-bite has caused a fatal hæmorrhage. The circulation is, in fact, in a great measure cutaneous; for the lungs, the stomach, the liver, and the kidneys, are as yet newly brought into activity, and feeble in their functions. If the infant, then, be rashly exposed to a cold atmosphere, the mass of blood previously circulating on the surface of the body is immediately driven inwards by the contraction of the cutaneous vessels, and, by deranging the action of the internal organs, gives rise to fever, bowel-complaints, inflammation, croup, or convulsions, which sooner or later extinguish life. Hence warm and light clothing is indispensable in infancy, and especially during the winter and spring months; and if, under a groundless expectation of hardening the constitution, the infant be daily plunged into cold water at that tender age, or rashly exposed to the open air during very cold weather, or to currents from doors or windows, the consequences can scarcely be otherwise than injurious.

In my *Treatise on the Physiological and Moral Management of Infancy,* I have entered into some details in proof of the great influence of cold on infant mortality, and particularly of that arising from a law in France, which requires newly-born children to be carried to the office of the *maire* to be registered—a custom which Dr Edwards has shewn to be productive of a rate of mortality directly proportioned to the coldness of the season and climate, and to the distance which the infant is carried from the parent's house. What more striking proof than this can be required of the evils arising from the ignorance of legislators in regard to the constitution of the human body? No man who understood physiology could ever have sanctioned a law, the practical effect of which is to consign annually so many victims to an untimely grave. The influence of cold on a large scale is strikingly shewn by the statistical researches of M. Herrmann on the mortality of Russia, where, according to him, of every 100 deaths, no less than 60 are those of infants. M. Quetelet likewise has pointed out, that in Belgium two infants die in January for one that dies in July.*

Many parents, however, from over-anxiety to avoid one form of evil, run blindfold into another scarcely less pernicious, and not only envelop infants in innumerable folds of warm clothing, but keep them confined to very hot and close rooms. It would be well for them to recollect that extremes are always hurtful, and that the constitution may be enfeebled, and disease induced, by too much heat and clothing, and too close an atmosphere, as effectually as by cold and currents of air. The skin, thus opened and relaxed, perspires too easily, and is readily affected by the slightest variations of temperature; whence arise those very colds and other ailments which it is the chief intention to guard against, while the internal organs, being at the same time deprived of their fair proportion of blood, become enfeebled, and afford inadequate nourishment and support to the rest of the body.

But it is not in infancy alone that sickness and mortality arise from the habitually imperfect regulation of the temperature of the skin. In youth, and especially during the debility arising from rapid growth, the proper regulation of the clothing demands more attention than is generally bestowed on it. Many delicate children suffer in winter from being allowed to go about within-doors with bare necks, arms, and legs; although their delicate appearance furnishes ample indication of the mischief thus produced, and their frequent attacks of illness might prove a warning even to unreflecting parents. This plan is resorted to by way of hardening the constitution, and instances of very robust children so treated are pointed to as proofs of its success. But the parent too often overlooks the fact that such children generally derive their vigour from the possession of an originally sound constitution, and that it is this circumstance alone which enables them to withstand, and perhaps even derive benefit from, the exposure to which they are subjected. But it is a very different thing, and the results are very different, when we apply the same discipline to a child of feeble stamina. Instead of strengthening its constitution, we are much more likely to bring about its premature death, or at all events to increase its delicacy and liability to disease.

A similar error from a similar motive is often committed at a later age by young people themselves. I have known many young persons, of both sexes, under this delusion go habitually about in winter and in cold weather with a dress light and airy enough for a northern summer. They thought it manly and becoming to do so; but those who were not very strongly constituted suffered a severe penalty for their folly. The necessary effect of a deficient circulation in the skin, is, as we formerly said, to throw a disproportionate mass of blood inwards; and when this condition exists, insufficient clothing perpetuates the evil, internal disease is generated, and health is perhaps irrecoverably lost before any apprehension of danger is felt. Insufficient clothing not only exposes the wearer to all the risk of sudden changes of temperature, but is still more dangerous (because in a degree less marked, and therefore less apt to excite attention till the evil be incurred), when of that kind which, while it is warm enough to guard the body against extreme cold, is inadequate to preserve the skin at its natural heat. Many youths

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* Nouveaux Élémens d'Hygiène, par Charles Londe, 3d ed., vol. i., p. 47. Paris, 1847.

—particularly females, and those whose occupations are sedentary—pass days, and weeks, and months, without ever experiencing the pleasant glow and warmth of a healthy skin, and are habitually complaining of chilliness of the surface, cold feet, and other symptoms of deficient cutaneous circulation. Their suffering, unfortunately, does not stop here; for the unequal distribution of the blood and lowered vitality too often, by insensible degrees, lay the foundation of tubercles in the lungs, and of other maladies, which shew themselves only when arrived at an incurable stage. Young persons of a consumptive habit will generally be found to complain of this increased sensibility to cold, and to exhibit the usual symptoms of internal congestion and impaired nutrition, even before they become subject to those slight catarrhal attacks which are so often the immediate precursors, or rather the first stages, of pulmonary consumption. All who value health, and have common sense and resolution, will therefore take warning from signs like these, and never rest till equilibrium of action be restored. For this purpose, warm clothing, exercise in the open air, and regular daily friction with a hair-glove or flesh-brush, are excellently adapted, and should be diligently pursued.

It is true that in youth the skin has a more vigorous constitution than in infancy; and that the several animal functions being now more equally balanced, the system is less susceptible of disorder from external causes, and can endure with impunity changes of temperature which at either an earlier or a more advanced age would have proved highly injurious. It is true, also, that the activity and restless energy of youth tend to keep up a free and equal circulation even in the remotest parts of the body, and that this free circulation tends in its turn to maintain an equality of temperature in them all. *Cold* bathing and lighter clothing, therefore, may now be resorted to with a rational prospect of advantage, provided they be properly regulated and duly proportioned to the state of the individual. *But when, from a weak constitution or unusual susceptibility, the skin is not endowed with sufficient vitality to originate the necessary reaction which alone renders these means safe and proper,—when they produce an abiding sense of chilliness, however slight in degree,—we may rest assured that mischief will inevitably follow at a greater or shorter distance of time from persevering in their use; and accordingly we should at once either modify or discontinue them.*

In seminaries for the young, and especially in boarding-schools, great mischief is often inflicted from inattention to this guiding principle. I have known many instances in which delicate young girls have suffered seriously and permanently from being confined to cold rooms in winter, with little or no fire, and with nothing beyond their ordinary in-door clothing, and, at the same time, on account of the weather, not allowed any active exercise in the open air by which their natural heat could be increased. The consequence has been a state of habitual suffering during many months of the year, a lowered tone of health, a retarded development of the constitution, a cold paleness of the surface and extremities, often accompanied by chilblains, and a spiritless languor of mind, which forms a striking contrast to the natural vivacity of youth. These evils, too, it is well to remark, are not inflicted from design, or even from carelessness. In most instances they spring from ignorance alone, and from a wish to harden the constitution, which they are in reality calculated to destroy. In boarding-schools for boys, I have known the same pernicious principles acted upon, and with lamentable consequences; but in them the evil is, to some extent, counteracted by the restlessness and craving for active exercise in the open air, which at that age can scarcely be repressed under any system of prohibitive discipline. A moderate acquaintance with physiology on the part of teachers would save them from this destructive error.

Habitual coldness of the feet is another source of suffering and bad health, both in schools and in general society; and in both it arises chiefly from inactivity or indolence. Sedentary females, literary men, clerks, &c., almost invariably suffer from this cause; and, in schools, even the young suffer from not being allowed sufficient exercise in active sports to circulate their blood. The formal boarding-school walk of half an hour or an hour *on fine days*, is a mere dull shadow of what exercise ought to be in youth, and is of no avail in infusing warmth and vigour into chilblained hands and feet. The production of heat stands in direct relation to the absorption of oxygen by the lungs and the quantity of carbonic acid and water thrown off by them and the skin. Valentin has shewn by experiment that slow sauntering exercise does not increase the pulmonary and cutaneous excretions, and consequently that it does not favour the vital metamorphoses on which the production of the animal heat depends.* But of this subject I shall have occasion to speak again in another chapter. In the mean time, I shall only caution the reader as to the use, or rather abuse, of artificial means for supporting the temperature of the body, and in particular of warm-water bottles now so commonly resorted to, to impart heat to the feet when in bed. Like all other substitutes for the operations of nature, warm bottles fail in the purpose for which they are used, and tend to aggravate the evil. Instead of promoting a healthier circulation through the vessels of the feet, they weaken by relaxing them, and leave them less able than before to generate *natural heat.* Every body admits that a warm foot-bath used every evening is relaxing and hurtful. Now a hot-water bottle in contact with the feet for hours every night acts on precisely the same principle, and proves scarcely less injurious. By the irregularity of circulation which it brings about, it induces flushing and headach, while it does not correct the cause of the coldness of the feet. In females, accordingly, it often produces a local weakness and discharge altogether incompatible with health. To remove such coldness, exercise, friction, and proper attention to diet and to the bowels, are the most effectual means; and, in addition to these, the use of the cold salt water foot-bath, for two or three minutes at a time, once or even twice a-day, will be very serviceable, by invigorating the circulation, and exciting a healthy reaction similar to the glow which comes on after sea-bathing. But to effect this in very languid constitutions, the physician generally finds it necessary to enjoin a smart walk immediately after the foot-bath. It is to the reaction induced by exercise after the application of cold, that hydropathy is indebted for many of its cures. The only legitimate use of hot-water bottles is to air or moderately warm the sheets, by placing two or three of them in different parts of the bed late in the afternoon, and having them removed at least an hour before going to bed. But even this indulgence should be resorted to only in aid of better means, and when there is positive necessity for external warmth. The plan of going to sleep with the feet in contact with a warm bottle is a very bad one, and ought never to be adopted as a habit.

The inactivity implied in a sedentary mode of life leads to another abuse, against which every one should guard. I allude to the overheating of sitting and bed-rooms by large fires or stoves. External heat thus applied invariably diminishes the heat-producing power of the animal system, and, as a necessary consequence, renders it more and more dependent on external warmth at the expense of increasing debility and susceptibility of cold. We shall afterwards see that the power of generating heat is much greater in winter than in summer, and that Nature has thus endowed the organism with the means of accommodating itself to the change of seasons. But if the body be accustomed to depend too much on an artificial temperature, its power of generating heat is weakened, and it becomes unable to resist the effects of exposure. Many persons, when cautioned on this subject, triumphantly point to a thermometer in the room as indicating a temperature of perhaps only 65°. But this is a fallacious test. There is a great difference between an equable temperature of 65° diffused *through the whole air* as in summer, and a corresponding temperature *in a part of any room, the air of which is rapidly and constantly changing.* To raise the thermometer of such a room to 65° in winter, at the distance of 10 or 15 feet from the fire, we must have a heat of perhaps 75° nearer the fire, and a large quantity of heat must be radiated from it, and directly absorbed by the body. In a room warmed by a large fire, too, there is constantly a strong current of air rushing towards the chimney, to which we have no parallel in the equable temperature of a summer-day. But the air thus entering the room from without is necessarily colder by very many degrees than the air contained in it; so that, to keep the thermometer steadily at 65°, we must maintain a fire large enough to *instantly* warm that large mass of cold air. To succeed in this, however, the fire must be such as to throw out by radiation and contact a quantity of heat far beyond what is present in the same quantity of air at the same apparent heat in summer, and by this radiated heat the body is scorched and relaxed. Whereas in summer, the walls, the furniture, and the air of the room being all at an equilibrium of heat, no such current or rapid loss is going on. The consequence is, that any one in winter coming from the open air into a room of a temperature of 65° at ten feet from the fire, will be apt to exclaim, How overheated the room is!—although those who are accustomed to it may affirm the contrary, and point for proof to the thermometer. This sensation of overheating is not the result of the mere transition; for no length of time will make the warmth agreeable to a healthy person of active habits, and, practically, those who indulge in the warmth certainly suffer all the evils arising from overheated rooms. I have so often observed this that I can speak on the subject with confidence. For invalids confined to the house it is a matter of much importance; and as a general rule, I consider a thermometrical temperature of 55° in winter in a bed-room or sitting-room, where there is a current of air, as fully equal to a steady temperature of 65° in summer, and consequently quite as high as ought ever to be indulged in.*

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* Lehrbuch, vol. i., p. 279.

For a similar reason, while sufficiency of clothing is attended to, excessive wrapping up must be as carefully avoided. Great differences in the power of generating heat and resisting cold exist in different individuals, and it would be absurd to apply the same rules to those who never feel cold, as to those who are peculiarly sensitive. The former may be benefited by cold bathing and degrees of exposure which would be fatal to the latter. Much, then, depends on the natural constitution of the individual and much on habit; and the effects of habit may even, it appears, in some degree become hereditary. Thus, Mr Darwin mentions that at a harbour of Tierra del Fuego, "a woman, who was suckling a recently-born child, came one day alongside the vessel, and remained there out of mere curiosity, whilst the sleet fell and thawed on her naked bosom, and on the skin of the naked baby."† But the effect of such exposure is to produce a hideous race, stunted in their growth, which "one can hardly make oneself believe are fellow-creatures, and inhabitants of the same world." The rule is, therefore, not to dress in an invariable way in all cases, but to put on clothing in kind and quantity *sufficient in the individual case to protect the body effectually from an abiding sensation of cold, however slight.* Warmth, however, must not be sought for in clothing alone, which, it ought to be remembered, serves but to retain heat, not to generate it. The source of the animal heat lies in the metamorphoses which the food and the tissues of the body are incessantly undergoing, and the Creator has made exercise essential as a means to produce the healthy performance of these metamorphoses. Consequently, if we neglect exercise and seek warmth in clothing alone, we act at the risk, or rather with the certainty, of weakening the body, relaxing the surface, and rendering the system extremely susceptible of injury from the slightest accidental exposures, or variations of temperature and moisture. Many good constitutions are thus ruined, and many nervous and pulmonary complaints brought on, to embitter existence, and to reduce the sufferer to the level of a hot-house plant.

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* The method usual in this country of heating rooms by open fireplaces, is liable to many objections. They occasion such strong draughts of cold air from the door and windows that an equable temperature cannot be maintained; while the consumption of fuel is unnecessarily great, from the escape by the chimney of the larger portion of the heat evolved. But as our houses are generally constructed without any provision for ventilation, these errors in heating are in some degree compensated by the incidental though imperfect introduction of fresh air. For full details on the subject we refer to a small work entitled "Practical Ventilation, &c., by Robert Scott Burn;" Edin. 1850.

† Darwin's Journal of Researches into the Natural History and Geology of the Countries visited during the Voyage of the Beagle, p. 213. London, 1845.

Female dress errs in one important particular, even when unexceptionable in material and quantity. From the tightness with which it is made to fit on the upper part of the body, not only is the insensible perspiration injudiciously and hurtfully confined, but that free play between the dress and the skin, which is so beneficial in gently stimulating the latter by friction at every movement of the body, is altogether prevented, so that the action of the cutaneous nerves and vessels, and consequently the heat generated, are rendered less than what would result from the same dress more loosely worn. Every part and every function are thus linked so closely with the rest, that we can neither act wrong as regards one organ without all suffering, nor act rightly without all sharing in the benefit.

We can now appreciate the manner in which wet and cold feet are so prolific of internal disease, and the cruelty of fitting up schools and similar places without making adequate provision for the welfare of their young occupants. The circumstances in which wet and cold feet are most apt to cause disease, are those where the person remains inactive, and where, consequently, there is nothing to counterbalance the unequal flow of blood which then takes place towards the internal parts; for it is well known that a person in ordinary health may walk about or work in the open air with wet feet for hours together without injury, provided he put on dry stockings and shoes immediately on coming home. It is therefore not the mere state of wetness that causes the evil, but the check to perspiration and the unequal distribution of blood to which the accompanying coldness gives rise. I am acquainted with an instance in which a robust and healthy tradesman, by incautiously standing when in a state of profuse perspiration, in the sea for five minutes in repairing a steam-boat, brought on severe constitutional disturbance, followed by pulmonary disease, which confined him to the house during the whole of *four* winters. Twenty-three years after the cause was applied, although his health was gradually improving, he still suffered from cough and breathlessness, and remained very susceptible of cold and illness from every trifling exposure. This person instantly shifted himself on coming out of the water, which at the time he had been led to believe was a sufficient precaution. But had he known something of his bodily constitution, he would have seen the danger before he exposed himself to it, and would have escaped the heavy suffering which his ignorance brought upon him.

The risk of injury from cold is very much increased when there has been much previous exercise, followed by exhaustion of the vital powers. Hence the danger incurred by sportsmen from wading and getting chilled after hard exercise, and by tourists in exposing themselves on the summits of mountains after a fatiguing ascent. We are acquainted with a gentleman who, for the sake of saving a detour of a few miles, swam across a lake after much previous exercise in shooting, and then waited on the shore for his less daring companions. The consequence was an attack of rheumatic fever which confined him to bed for many months, and the severity of which made his recovery long appear hopeless.

The preceding observations refer chiefly to the quantity and fitting of the clothing; but *the material of which it is composed* is also a consideration of much importance. The principal requisites are, that the dress shall be, 1*st*, as light as possible; 2*dly*, a bad conductor of heat, so as to afford protection against sudden changes of temperature; and, 3*dly*, of so porous a nature as to admit of the easy passage of the insensible perspiration. Of the various kinds of clothing in common use, none presents these advantages combined in so high a degree as flannel; and consequently, as a general rule, no other material can equal it in suitableness for being worn in contact with the skin, which it is our chief object to protect.

The advantages of wearing flannel next the skin have been long and familiarly known, and they are easily explicable on the principles above expounded. Being a bad conductor of heat, flannel prevents that of the animal economy from being quickly dissipated, and protects the body in a considerable degree from the injurious influence of sudden external changes. From its presenting a rough and uneven though soft surface to the skin, every movement of the body in labour or in exercise, gives, by the consequent friction, a gentle stimulus to the cutaneous vessels and nerves, which assists their action, and maintains their functions in health; and, being at the same time of a loose and porous texture, it is capable of giving a readier passage to the cutaneous exhalations than any other material in common use—while, from the cellulated structure of the fibre of the wool, its tissue does not become saturated with moisture, as is the case with linen, whenever there is a flow of perspiration. In some very delicate constitutions, however, it proves too irritating to the skin, and in hot climates is apt to excite too great a flow of perspiration. In the former case, fine fleecy hosiery, and in the latter, cotton, will in general be easily endured, and will greatly conduce to the preservation of health.

Many are in the custom of waiting till winter has fairly set in before beginning to wear flannel. This is a great error in a variable climate like ours, especially when the constitution is not robust. *It is during the sudden changes from heat to cold, which are so common in autumn, before the frame has got inured to the reduction of temperature, that protection is most wanted, and flannel is most useful; and also during the sudden transitions in spring.* Even in summer the temperature at different times of the day, and the degrees of exercise in which we are engaged, are so very different, that flannel is then scarcely less valuable as a protection than during the colder months of the year. Towards sunset the air often becomes so cold in summer after a very warm day, as to cause a sudden chill to those who are not on their guard against it. This is a frequent occurrence even in the climates of France and Italy, from the moisture which is then condensed by the cooling of the air; and hence invalids ought to be particularly cautious not to expose themselves at this time, as the chilled skin becomes a ready vehicle for the absorption of miasmata. Upon the whole, therefore, I am disposed to recommend persons of a delicate constitution not to leave off the use of flannel even in summer, but rather, if they find it too warm, to wear it over the shirt, instead of under, as in winter. This will modify its effects, and at the same time scarcely impair its power of protecting against sudden changes.

The advantages of flannel as a preservative from disease, in warm as well as in cold climates, are now so well understood, that in the army and navy its use is cogently, and with the greatest propriety, insisted on. Sir George Ballingall, in his valuable *Lectures on Military Surgery* (p. 92), has some very judicious remarks on the influence of warm clothing in preserving the health of soldiers. After adducing the testimony of Sir James Macgrigor, to shew that in the Peninsula the best-clothed regiments were generally the most healthy, Sir George mentions that when in India, he had himself a striking proof of the utility of flannel in checking the progress of a most aggravated form of dysentery in the second battalion of the Royals. In like manner, Captain Murray, late of H.M.S. Valorous, told me, that he was so strongly impressed by former experience with a sense of the efficacy of the protection afforded by the constant use of flannel next the skin, that when, on his arrival in England in December 1823, after two years' service amid the icebergs on the coast of Labrador, the ship was ordered to sail immediately for the West Indies, he directed the purser to draw two extra flannel shirts and pairs of drawers for each man, and instituted a regular daily inspection to see that they were worn. These precautions were followed by the happiest results. He proceeded to his station with a crew of 150 men; visited almost every island in the West Indies, and many of the ports in the Gulf of Mexico; and, notwithstanding the sudden and extreme transitions from climate to climate, returned to England without the loss of a single man, or having any sick on board when he arrived. It would be going too far to ascribe this excellent state of health solely to the use of flannel; but there can be little doubt that this was one of the chief causes of Captain Murray's success. Far, however, from trusting to it alone, he was as careful in guarding against other sources of disease as against variations in temperature; and with this view every precaution was at the same time used, by lighting stoves between decks and scrubbing with hot sand, to ensure the most thorough dryness, and proper means were put in practice to promote cheerfulness among the men. When in command of the Recruit gun-brig, which lay about nine weeks at Vera Cruz, the same measures preserved the health of his crew, when the other ships of war, anchored around him, lost from twenty to fifty men each.

That the superior health enjoyed by the crew of the Valorous was attributable chiefly to the means employed by their humane and intelligent commander, is shewn by the analogy of the Recruit; for although constant communication was kept up between this vessel and the ships in which sickness prevailed, and all were exposed to the same external causes of disease, yet no case of sickness occurred on board of it. Facts like these are truly instructive, by proving that man possesses much power of protecting himself from injury, when he has received the necessary instruction, and chooses to adapt his conduct to the circumstances in which he is placed.

In further corroboration of the utility of flannel in preserving health, I may quote the following remarks by the late Dr Hope of London. "For eight or ten years," says he, "I have been in the habit of asking the question of all respectable patients of robust constitution, who had been attacked with pleurisy, peripneumony, or acute rheumatism, whether they were in the habit of wearing flannel or not: to which they generally answered in the negative—the common reason assigned being that they were so much exposed that they could not venture to pamper themselves. I recently put the same question to a London physician, and he gave the same answer with a smile and 'My dear friend, it is impossible, &c.' He was attacked with rigors the same night, and had a severe rheumatic fever. I do not quote the poorer classes, for they almost universally are deterred from wearing flannel by the expense, and it is notorious that they are subject to acute inflammations of all kinds in a much greater proportion than the higher classes. Flannel is also highly beneficial to chronic affections of the mucous membrane of the lungs."*

When, from any reason, flannel or fleecy hosiery cannot be worn next the skin, cotton should be preferred to linen as a substitute. In summer, it is true, the latter feels much cooler and fresher; but from this very quality, which arises from its being a good conductor of heat, it is less serviceable in protecting the body from chills. Besides, owing to the porous nature of its fibre, it greedily imbibes the moisture of the perspiration, and forms a damp covering to the body, which readily abstracts the heat from the surface, and produces an unpleasant feeling of cold. Checked perspiration ensues, possibly to be followed by inflammatory colds or rheumatism. These evils may in a great measure be guarded against by wearing flannel outside the linen; but when this is objected to, as will generally be the case in warm climates, the best and most convenient substitute will be found in cotton, which possesses the combined advantages of being a bad conductor of heat, and of not imbibing moisture with the same facility as linen. Consequently the risk of chill is very much diminished. Silk has likewise been recommended as a convenient and pleasant substitute for flannel next the skin: it has the advantages of being a bad conductor of heat, and having a smaller disposition to absorb moisture than even cotton. Its greater price, however, is an obstacle to its general adoption; while in very sensitive persons it is said to prove a source of irritation, and to produce cutaneous eruptions.†

With regard to the upper clothing, it is impossible to lay down any fixed rules: all that can properly be said is, that it should be light, free, and unrestrained, and in such quantity as to afford the necessary protection without relaxing the surface too much. It ought, therefore, to vary, not only according to the season and the weather, but according to the active or passive state of the wearer. As active exertion is favourable to the production of animal heat, less clothing is necessary for walking than for driving or sailing. For this reason we see the labourer strip in proportion to the severity of his toil, while the passive female in a well-hung carriage lolls wrapped up in cloaks and furs. But when overheated by exercise, we should be careful not to throw aside our wrappings too suddenly after coming home. The safest way is to saunter about the room for a few minutes till the natural heat be attained, and then to throw off the superfluous covering; or when the exercise has been severe and the under garments are wet with perspiration, it is better at once to change them before a chill ensues. Many suffer from neglecting these precautions, and blame the walking out for the cold which they caught rather after their return. In like manner, many injure themselves in severe weather by getting chilled before going out, and trusting to subsequent exercise to restore their heat; whereas going out already cold is the surest way to get thoroughly chilled, and to be hurt by it. Those resist external cold best who leave the house comfortably warm, and with an active state of the cutaneous circulation.

To a certain extent the colour of the clothing must modify its power of preserving the warmth of the body; but its heat-retaining quality is so much more dependent on the texture than on the colour of the garments, that the consideration of colour is not one of much practical importance.

In aid of the third requisite of clothing—that it should be sufficiently porous to give easy passage to the insensible perspiration, and sufficiently absorbent to take up a considerable portion of moisture when sweating is induced,—it is necessary that whatever is worn should be frequently changed, ventilated, and washed, to free it from the impurity necessarily arising from so constant and extensive an exhalation from the skin. In the case of flannel, for example, it is an excellent plan, instead of wearing the same garment for several successive days, either to change it very frequently, or to make use of two sets of flannel, each being worn and aired by turns on every alternate day. A frequent change, however, is certainly the preferable arrangement. For the same reason, a practice common in Italy merits universal adoption. Instead of beds being made up in the morning the moment they are vacated, and while still saturated with the nocturnal exhalations, which, before morning, even become sensible to smell in a bedroom, the bed-clothes are thrown over the backs of chairs, the mattresses shaken up, and the window thrown open for the greater part of the day, so as to secure a thorough and cleansing ventilation. This practice, so consonant to reason, imparts a freshness which is peculiarly grateful and conducive to sleep; and its real value may be inferred from the well-known fact, that the opposite practice, carried to an extreme—as in the dwellings of the poor, where three or four beds are often huddled up with all their impurities in a small room—is a plentiful source of fever and bad health, even where there is no deficiency of nourishment or of ventilation during the day. In the abodes of the poor Irish residing in Edinburgh, I have seen bedding for fourteen persons spread over one floor not exceeding twelve feet square: when morning came the beds were huddled one above another to make sitting-room during the day, and at night they were again laid down, charged with accumulated exhalations. If fever were not to appear in such circumstances, it would be indeed marvellous; and we ought to learn from this, that if the extreme be so injurious, the lesser degree implied in the prevalent practice cannot be wholesome, and therefore should not be retained when it can be so easily done away with.

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* Notes on Chronic Pleurisy, by the late James Hope, M.D.; Med.-Chir. Rev., July 1841, p. 300.

† Wilson on the Skin, 2d ed., p. 146.

The exhalation from the skin is composed of about 986 parts of water and 14 of animal and mineral substances per 1000; or, assuming the water exhaled in 24 hours to amount to 25·5 ounces, the proportion of animal matter excreted in the same time would be about 2 drachms, and of inorganic salts about 41 grains. The animal matter consists principally of butyric and other fatty acids, of lactic and acetic acids, partly free and partly in combination with ammonia, and of some ill-defined extractive matter containing sulphur; the inorganic ingredients are chiefly common salt and the earthy phosphates, with minute quantities of ammoniacal salts. The excreted matter differs in composition in different regions of the body. When pure it is slightly acid, and has a slight odour, which becomes very perceptible when a number of individuals are crowded together. This odour varies in different animals, and accordingly by its means we readily distinguish whether we are in the neighbourhood of a flock of sheep, a herd of cattle, or a troop of horses. In man the perspiration, when mixed with the secretion of the sebaceous follicles, frequently becomes alkaline, and then acquires a strong, and in some individuals a very offensive smell, which, of course, is most perceptible where the sebaceous follicles abound, as, for instance, in the armpits. Frequent ablution of such parts is thus necessary for the sake of personal cleanliness, as well as to avoid being offensive to others. It cannot fail to be remarked how small the proportion of animal matter excreted by the skin is to that of the water, and some will feel at a loss to reconcile the results obtained by chemistry with the undoubted importance of the cutaneous excretion. But it is our limited knowledge which is here at fault. We have already seen how retention of the perspiration affects the chemico-vital metamorphoses; and we know, moreover, that many animal principles, when introduced into the blood even in the smallest quantities, produce most violent disturbance of the animal functions. It is probable that poisons of a similar nature are produced during the transformation of the tissues, and that these, if retained in the system, would act most injuriously upon it. The deleterious action of concentrated animal effluvia gives countenance to this view; while the objection, that the existence of such poisons has never been proved by the chemist, can be made only by those who are ignorant of the difficulties which, in the present state of our knowledge, attend such investigations.

The frequent removal of the saline and animal residue of the perspiration from the skin becomes, then, an indispensable condition of health, the observance of which, particularly in early life, when waste and nutrition are both very active, prevents the appearance of the cutaneous diseases otherwise so common in infancy.* Not only, therefore, is daily washing of the body required at that and indeed at every age, but frequent change of clothing is also essential; and for this reason it is much to be wished that a plan of washing the clothes of the poor at a cheap rate, were universally adopted. The trouble, time, and expense, imposed upon the mother of a family among the working classes in washing and drying the clothes of its individual members, are so great as to present an almost irresistible temptation to the neglect of cleanliness; and when we wonder at the dirt and disorder of a labourer's house, we are too apt to forget the disadvantages under which its inmates are placed, and the cost of toil and money at which cleanliness is obtained where there are several children to be taken care of, and cooking and other household operations to be conducted at the same time. Hence, among the poorer classes in large towns, want of cleanliness prevails to a very great extent, and proves highly injurious to both health and morality. Actuated by such considerations as these, a few benevolent individuals in Liverpool combined, a few years ago, to hire and fit up a cellar in a convenient situation, with the requisite boilers, tubs, and drying stoves, where the poor might have the means of washing their bed and body clothes at an exceedingly trifling expense of both time and money; and after several years' trial the results have been most encouraging. Not only have the poor been eager to avail themselves of the privilege thus held out to them, but numerous instances have occurred in which the spread of disease was arrested, and health and character were restored, by the habits of cleanliness and self-respect thus fostered. The example has been followed with the best success in London, Manchester, and various other large towns in England; and there is every reason to hope that ere long a similar plan will be carried into execution in the different districts of every considerable town, and will even be extended to country villages.

But if the frequent change and washing of clothes are essential to the health of the skin by removing the saline and animal impurities deposited upon them by the perspiration, it is equally certain that frequent *bathing or washing of the skin* is not less indispensable to remove the impurities adhering to its surface, and which, if allowed to accumulate, would tend to obstruct its pores, impede its functions, and disturb its health. It is apparently for this reason that, in the eastern and warmer countries, where perspiration is very copious, ablution and bathing have assumed the rank and importance of religious observances. Those who are in the habit of using the flesh-brush daily, are at first surprised at the quantity of white dry scurf which it brings off; and those who take a warm bath for half an hour at long intervals, cannot have failed to notice the great amount of impurities which it removes, and the grateful feeling of comfort which its use imparts.* The warm, tepid, cold, or shower bath, as a means of preserving health, ought to be in as common use as a change of apparel, for it is equally a measure of necessary cleanliness. Many, no doubt, neglect this, and enjoy health notwithstanding; but many, very many, suffer from its omission, and even the former would be benefited by employing it. The perception of this truth is gradually extending, and baths are now to be found in fifty places for one in which they could be obtained twenty years ago. In many of our large towns baths for the working classes have been established along with the washing-houses, and the opportunities thus afforded of cultivating habits of personal cleanliness have been seized on with avidity.[*] To such an extent has this been the case that the Corporation of Liverpool has already seen fit to vote an expenditure of £40,000 for these erections; £16,000 has been laid out for a similar purpose by the parish of St Martins-in-the-Fields in London, and a correspondingly large sum by the parish of Marylebone, while other metropolitan bodies are preparing to follow in the same path. The movement is thus rapidly spreading, and promises to be productive of the greatest benefit to the health and morality of the working population. In the use of the bath, however, the middle and upper classes in this country are greatly behind the corresponding classes in France. This will at once be evident on comparing the bathing accommodation afforded in the two countries. For instance, in the year 1845 Paris contained for the public use 2709 baths, in different establishments throughout the city, and 1059 portable baths for the use of invalids and others who preferred using them in their own houses;[†] [‡] while Edinburgh, on the other hand, has only three bathing establishments, containing altogether under 40 baths, and the thriving city of Aberdeen, with a population of 65,000 in 1841, had no public warm fresh water bath till 1851, when an old church was converted into a bathing establishment containing 19 hot and cold baths on the upper floor and a large swimming bath below. Formerly the opportunities enjoyed by the working classes also, of using the warm bath, were greater in France than in England, but the establishment of the Baths and Wash-houses has of late years turned the scale. This pre-eminence, however, may be but temporary, as the French Government, with a laudable desire to promote the formation and development of institutions which are for the benefit of the people, after sending M. Pinède to collect information regarding the English establishments, has appointed a commission to prepare a bill for instituting public baths and wash-houses for the industrious classes.

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* See the author's work on the Management of Infancy, 7th ed., p. 85.

* Valentin obtained, by currying a horse weighing 948 lbs., on one day 91 grains of epidermic scales, mixed with some broken pieces of hair and residue of perspiration, and on the following day 65 grains.—*Lehrbuch*, vol. i., p. 622.

When we consider the importance of the exhaling functions performed by the skin, it seems almost incredible that ablution and bathing of every description should be so much neglected in charitable institutions, in seminaries for the young, and even by many persons who consider themselves patterns of cleanliness. Mr Stuart, in speaking of the North Americans, remarks that "the practice of travellers washing at the doors, or in the porticos or stoops, or at the wells of taverns and hotels once a-day, is most prejudicial to health; the ablution of the body, which ought never to be neglected, *at least twice a-day* in a hot climate, being altogether inconsistent with it." "In fact," he adds, "I have found it more difficult in travelling in the United States, to procure a liberal supply of water at all times of the day and night in my bed-chamber, than to obtain any other necessary. *A supply for washing the face and hands once a-day seems all that is thought requi-*

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[*] Nearly 300,000 baths were taken in the first year in the Goulston Street and St Martin's establishments in London.

[†] Lévy, Traité d'Hygiène, vol. ii., p. 679.

[‡] It is calculated that 2,116,300 baths are taken annually in Paris, at an average cost of 60 centimes or 6d. per bath, besides those which are given gratis in the hospitals.

site."* This state of matters still continues pretty nearly the same, except in the great Atlantic cities, where some degree of improvement has taken place. But bad as it is, I fear that numbers of sensible people may be found much nearer home, who limit their ablutions to the *visible* parts of their persons, and would even express surprise if told that more than this is necessary to health. Certain it is that many never wash their bodies unless they happen to be at sea-bathing quarters in summer, or are oppressed with heat, when they will resort to bathing as a means of comfort, but without thinking at all of its efficacy, *as a means of cleanliness*, in preserving health. In many public charities and schools, in like manner, bathing or ablution is never thought of as a proper or practicable thing, except for the sick; and yet it is obviously of great importance to every one, especially to the young.† These facts shew that there is quite as much truth as sarcasm in the remark of a medical journalist, that "we every day see whole families purged and vomited by the order of their physicians, but rarely or never do we hear of their being recommended to wash their skins."‡

For *general* use, the tepid or warm bath seems to me much more suitable than the cold bath, especially in winter, and for those who are not robust and full of animal heat. Where the constitution is not vigorous enough to secure reaction after the cold bath, as indicated by a warm glow over the surface, its use inevitably does harm. A vast number of persons, especially of those leading a sedentary life, are in this condition; while, on the contrary, there are few indeed who do not derive evident advantage from the regular use of the tepid bath, and still fewer who are hurt by it.

Where the health is good, and the bodily powers are sufficiently vigorous, the cold bath during summer, and the shower-bath in winter, may serve every purpose required from them. But it should never be forgotten that they are too powerful in their agency to be used with safety by *every one*, especially in cold weather. In proportion as cold bathing is influential in the restoration of health when judiciously used, it is hurtful when resorted to without discrimination; and invalids therefore should never have recourse to it without the sanction of their professional advisers.

Even where cold bathing is likely to be of service when judiciously employed, much mischief often results from continuing the immersion too long. I once met with a case of this kind in a boy of fifteen years of age, who became nearly insensible from remaining half an hour in the sea, while bathing at Portobello: it was some days before he was sufficiently restored to be considered out of danger. Even in the most vigorous subjects, prolonged immersion is very apt to be followed by injurious effects; and the danger is greater the lower the temperature of the water. On plunging into moderately cold water, a comfortable feeling follows after the first shock has subsided; and if the bather quit the water before this stage passes away, the whole surface of the body will soon be overspread with a genial glow. But if immersion be farther prolonged, the blood is driven in upon the internal organs, the nervous energy is depressed, and, reaction being prevented, injurious consequences will probably ensue.

The experiments of Chossat have

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* Three Years in America, vol. ii., p. 440.

† While revising these pages, I have learned from a friend the particulars of a case strikingly illustrative of the necessity of attending to the condition of the skin, and of the sympathy subsisting between it and the bowels. A lady, who is in other respects very cleanly in her habits, has never been accustomed to the use of the bath, or to general ablution of any kind, and, in consequence, the action of the skin is very imperfect. As a substitute, however, for its exhalation, she has, all her life, been affected with *bowel-complaint*, which no treatment, directed to the bowels, has been able to remove. It is probable that the natural course of the exhalation could not now be restored.

‡ Medico-Chirurg. Rev., No. LXVI. p. 523.

shewn that in a large proportion of chronic diseases the immediate cause of death is the reduction of the temperature of the body. This is the case in starvation. Life continues so long as the body yields, through absorption of its tissues, a supply of fuel for the purpose of respiration; but when this is exhausted the temperature falls, and death ensues. The energy with which the vital functions are performed thus stands in a direct relation to the temperature of the body, and consequently decreases with the latter. For instance, when the temperature of turtle-doves, which, in the normal state, is 108° F., fell to 99°, the muscular contractions ceased to be vigorously performed, and fatigue was easily induced. When it fell to 90°, the birds lost the power of standing, and were obliged to rest the belly on the ground; and at 74° life became extinct. That death was really caused by cold was evident from the marvellous effects of artificial heat in recalling vigour to animals which were on the point of expiring. Pigeons gradually recovered so far as to be able to perch on the finger, and even to fly short distances; while death immediately followed on the withdrawal of the heat. These experiments tend to throw light on the cause of danger from prolonged immersion in water at a low temperature. The heat of the body is abstracted, its temperature becomes too low for the normal performance of chemico-vital metamorphoses, and one of the first consequences is weakness of muscular contraction. This every one must have experienced in the difficulty of fastening the dress when the hands are chilled. We constantly read of accidents occurring to persons while bathing. A good swimmer plunges boldly into deep water, and strikes out manfully from the shore. But he soon tires and makes for the land; he is seen to struggle in the water, and, before assistance can be rendered him, he sinks and is drowned. He is said to have been seized with cramp; but the real cause of death, in the majority of instances, is the action of cold, enfeebling vital action. Hence bathers, especially those of spare and slender bodies, should beware of venturing into deep water, more particularly at an early stage of the season, before the sun's influence has raised the temperature. Such accidents are peculiarly apt to happen when bathing is resorted to for refreshment, after a long and fatiguing day's walk.

But even when the results are not so directly injurious, the system suffers from the depression of the vital energies, which is sufficiently evident in the defective powers of reaction. An uncomfortable feeling of chilliness is produced, which often continues throughout the remainder of the day. In delicate subjects, injury is frequently caused by cold bathing at a time when the vital powers are too languid to admit of the necessary reaction—before breakfast, for example, or after fatigue. For this reason, many persons who, when they bathe in the morning before taking any sustenance, do not soon recover their natural heat and elasticity of feeling, derive much more benefit from bathing early in the forenoon.

Great care should at all times be taken by bathers not to enter the water when they are cold. A smart walk for a few minutes along the beach, so as to produce a comfortable glow, will favour reaction, and cause cold bathing to be well supported even by delicate persons. When the constitution is feeble, river-bathing should be avoided, as the heat of the body is abstracted with a rapidity proportionate to the strength of the current. In hilly countries, too, the water of rivers, descending rapidly from a height, is exceedingly chilly, even in the middle of summer, and gives a shock for which the bather, misled by the warmth of the air, is totally unprepared.

For those who are not robust, daily sponging of the body with cold water, cold water and vinegar, or salt water, is the best substitute for the cold bath, both as a means of freeing the skin from its impurity and as a tonic: it may be resorted to with safety and advantage in most states of the system;

especially when care is taken to excite on the surface, by subsequent friction with the flesh-brush or hair-glove, the healthy glow of reaction. It then becomes an excellent preservative from the effects of changeable weather. When, however, a continued sensation of coldness or chill is perceptible over the body, cold applications should not be persisted in; tepid sponging, aided by dry friction, is then greatly preferable, and often proves highly serviceable in keeping up the due action of the skin. But it very rarely happens that cold sponging is not well borne, when used *immediately* on getting out of bed, while the body still retains a comfortable glow.

For habitual use, the *tepid or warm bath* is certainly the safest and most valuable, especially during the autumn, winter, and spring, and for invalids; and every house should be provided with one as an indispensable requisite for health and comfort. A temperature ranging from 85° to 90°, according to the state of the individual, is the most suitable; and the duration of the immersion may vary from fifteen minutes to an hour or more, according to circumstances. As a general rule, the water ought simply to be warm enough to feel pleasant without giving a positive sensation of heat; the degree at which this happens varies considerably according to the constitution and to the state of health at the time. Sometimes, when the generation of animal heat is great, a bath at 95° will be felt disagreeably warm and relaxing; while, at another time, when the animal heat is produced in deficient quantity, the same temperature will cause a chilly sensation. The rule, then, is to avoid equally the positive impressions of heat and of cold, and to seek the agreeable medium. A bath of the latter description is the reverse of relaxing; it gives a healthful tone and activity to all the functions, and may be used every day, or on alternate days, for fifteen or twenty minutes, with much advantage—though a bath once a-week, when daily sponging with cold water is used besides, will generally be sufficient to keep the skin in a healthy state.

A person of sound health and strength may take a bath at any time, except immediately after meals. But the *best* time for valetudinarians is in the forenoon or evening, two or three hours after a moderate meal, when the system is invigorated by food, but not oppressed by the labour of digestion. When the bath is delayed till five or six hours after eating, delicate people sometimes become faint under its operation, and, from the absence of reaction, are rather weakened by the relaxation it then induces. As a general rule, active exertion should be avoided for an hour or two after using the warm or tepid bath; and unless we wish to induce perspiration, it ought not to be taken immediately before going to bed—or if it is, it should be merely tepid, and not of too long duration.

These rules apply of course only to persons in an ordinary state of health. If organic disease, headach, feverishness, constipation, or other ailment exist, bathing ought never to be employed without medical advice. When the stomach is disordered by bile, it also generally disagrees. Under ordinary circumstances, however, and with ordinary prudence, the warm bath is not only a safe and valuable preservative of health, but an active remedy in disease. Instead of being dangerous by causing liability to cold, it is, when well managed, so much the reverse, that the author of these pages has used it much and successfully for the express purpose of diminishing such liability, both in himself and in others in whom the chest is delicate. In his own instance, in particular, he is conscious of having derived much advantage from its regular employment, especially in the colder months of the year, during which he has uniformly found himself most effectually strengthened against the impression of cold, by repeating the bath at shorter intervals than usual.*

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* I am delighted to find my opinion of the value of the bath and of attention to the cutaneous functions in the prevention

Considering the nature of the occupations in which most of the labouring classes are engaged, and the soothing and refreshing effects as well as the cleanliness derived from the use of the tepid bath, there cannot be a doubt that a great public benefit will be attained by providing baths for their use at a very easy rate, and encouraging them to resort to them by personal influence and frequent expositions of their advantages. In many factories where there is constantly steam or warm water running waste, baths for the workmen and their families might be fitted up at a very trifling cost, and their use do much to subdue that craving for stimulus which drives so many to the gin-shop; and also to allay that irritability of mind so apt to be induced by excessive labour. When the trade is dirty, a tepid bath and change of clothing on quitting it for the day would be the saving of many men who at present fall into vice by imperceptibly losing that self-respect and regard for decency of appearance which are among the strongest safeguards of character and morality; and I rejoice to think that in several manufactories the hint thrown out in the former editions of this work has been acted upon, and followed by more than the expected advantages. To derive full benefit from it, however, some knowledge of the animal economy must be communicated, and a desire excited among the more intelligent workmen to avail themselves of the boon. The more ignorant and unintellectual the individual, the less will he appreciate the offered advantage; but patient and good-humoured encouragement will soon get over all difficulties, and excite a right feeling on the subject.

On the Continent, vapour and hot air baths are had recourse to both as an agreeable means of removing the impurities and exciting the action of the skin, and for the cure of disease, to a vastly greater extent than they are in this country. Their use is attended by the very best effects, particularly in chronic ailments, and where the water-bath is felt to be oppressive by its weight; and there can be no question that their action is chiefly on the skin, and through its medium on the nervous system. As a means of cleansing the skin, determining the blood to the surface, promoting cutaneous exhalation, and equalising the circulation, they are second to no remedy now in use; and consequently, in a variety of affections which the encouragement of these processes is calculated to relieve, they may be employed with every prospect of advantage. The prevalent fear of catching cold, which deters many from using the vapour-bath, even more than from warm bathing, is founded on a false analogy between its effects and those of profuse perspiration from exercise or illness. The latter weakens the body, and, by diminishing the power of reaction, renders it susceptible of injury from sudden changes of temperature. But the effect of the vapour-bath properly administered is very different. When not too warm or too long continued, it not only removes a load of impurities beyond what was imagined to exist, but increases instead of exhausting the strength; and, by exciting the vital action of the skin, gives rise to a power of reaction which enables it to resist cold better than before. This I have heard many patients remark; and the fact is well exemplified in Russia and the north of Europe, where it is the usual practice of the natives to have a bucketful of cold water thrown over the body immediately after leaving the vapour-bath. The application, far from being disagreeable, produces a grateful sensation;* but were the same practice resorted to after severe perspiration from exhaust-

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of pulmonary disease, and indeed the whole practical doctrines of the present chapter, corroborated by the authority of Sir James Clark, in his admirable works on Consumption and Climate. Both treatises are well deserving the attention of parents and others interested in the health of the young, and especially of those who are delicately constituted.

* Life of a Travelling Physician, by Sir George Lefevre.

ing exercise, there can be no doubt that serious injury would ensue. It is the previous stimulus given to the skin by the vapour-bath, which is the real safeguard against the coldness of the water.

The truth of this principle is strikingly illustrated by the practice which was first introduced by Priessnitz at Græfenberg, and has since spread to various other parts of Germany, and also to England and Scotland, of treating diseases by first inducing severe sweating, and then administering the cold bath, not only daily, but several times a-day. The patient is first stripped naked and wrapped up rather tightly in blankets, and laid down till sweating comes on, which seldom happens in less than an hour. As soon as this commences, the window is thrown open, and he is made to drink a glassful of cold water every quarter of an hour or half hour. This increases the perspiration so much that the sweat sometimes drops from the blanket to the extent of seven pounds weight. When the sweating has continued sufficiently long the patient is unswathed, and, covering himself with a cloak, hurries to the cold bath, *into which he plunges bathed in perspiration.* While in the bath he is made to exercise his limbs as much as possible, and, on leaving it, is required to take a sharp walk in order to excite the necessary cutaneous reaction. The greater the reaction, the more favourable will be the result.

According to ordinary notions, this practice would seem to be of the most dangerous character; but in reality it is not so; for, when judiciously managed, it is both safe and advantageous. Priessnitz admits, as every body does, that cold drinks, or the cold bath, *in a state of violent perspiration from exercise or the use of sudorifics*, is very dangerous; but one grand point of difference between such a state and that in which he prescribes cold bathing is, that, according to his plan, the powers of the system are rather excited than exhausted, and are thus ready to concur in undiminished force in the necessary reaction. But in sweating after violent exercise or sudorifics, the respiration and circulation have, as he justly remarks, already been excited, and are to a proportionate extent exhausted, so that they are overpowered instead of being roused to reaction by the cold. Hence, he affirms, *provided the breathing is not hurried, and the surface is not chilled by exposure to the air* before plunging into the cold bath, no risk whatever is incurred, however copious the perspiration. Active exercise, however, is most wisely and strenuously urged as a part of the treatment.

Common experience affords another illustration of the principle implied in the caution to avoid becoming chilled before going into the cold bath. If, in a cold winter day, we chance to sit for some time in a room imperfectly warmed, and feel, in consequence, a sensation of chilliness over the body, we are much more likely to catch cold on going out than if we had been sitting in a room comfortably warm. In the latter case, the cutaneous circulation and nervous action go on vigorously; heat is freely generated, and the vital action of the skin is in its full force. The change to a lower temperature, if accompanied with exercise to keep up vitality, is then felt to be bracing and stimulating rather than disagreeable. But it is widely different when the surface is already chilled before going out. The vitality of the skin being diminished, reaction cannot follow additional exposure; the circulation leaves the surface and becomes still more internal; and if weakness exist in the throat or chest, a cold is the almost certain result. Many suffer from ignorance of this principle.

The vapour-bath is thus calculated to be extensively useful, both as a preservative of health and as a remedial agent. Many a cold and many a rheumatic attack, arising from checked perspiration or long exposure to the weather, might be nipped in the bud by its timely use. In chronic affections, not only of the skin itself, but of the internal organs with which it most closely sympathizes, as the stomach and intestines, the judicious application of the vapour-bath is productive of great relief. Even in chronic pulmonary complaints, it is, according to the Continental physicians, not only safe, but very serviceable; particularly in those affections of the mucous membrane which resemble consumption in so many of their symptoms. It is also strongly recommended by Dr Daniell in the treatment of tropical fevers. "After a careful observation," says he, "of the good effects of this remedial system, I was led to pay more particular study to the utility of its application, and at length to try a modified adaptation of it for the cure of those adynamic remittent fevers so destructive to European life. I have no hesitation in asserting, that not only myself, but many others who have experienced its efficacy by the speedy restoration to health, can vouch for its superiority over the ordinary practice of venesection, saline purgatives, and large doses of calomel."[*] Like all powerful remedies, however, the vapour-bath must be administered with proper regard to the condition and circumstances of the individual; and care must be taken to have the feet sufficiently warm during its use. If, from an irregular distribution of the steam, the feet be left cold, headach and flushing are almost sure to follow.. It is, therefore, a good precaution to place the feet in a vessel of tepid water.

Vapour is a much less perfect conductor of caloric than water, and therefore requires to be at a higher temperature to give the skin as much of the feeling of heat. The sensation produced by vapour at 98° and at 122° F., is about equal to that produced by water at 88° and 100°; and a considerably higher degree of heat can therefore be supported in the vapour than in the warm bath. As a general rule, however, 120° F. is the highest limit within which the heat can be comfortably borne in the vapour-bath in the sitting posture, though, when the patient is lying, an addition of several degrees may be supported.

The vapour-bath is taken either by entering entirely a chamber into which the vapour is admitted, or by enclosing the body in a box from which the head is excluded. The former method is that generally adopted in Russia and the East; the latter is that which is chiefly used in this country.

It happens occasionally, either from some peculiarity of constitution, or from an unusual condition of the skin, indicated by great dryness and a liability to erysipelatous and scaly eruptions, that the moisture of the water or vapour-bath is at first rather prejudicial and unpleasant, and becomes grateful only in proportion as the skin regains its healthy state. In such cases the warm *air-bath* is said to be remarkably successful, and is rapidly gaining ground in the metropolis.

Although the preceding remarks apply specially to the skin considered as an *exhalant*, yet most of them are equally applicable to it when viewed as the seat of an important *nervous* function. For, so intimately and beautifully are all the parts of the frame connected with each other, that what is really good for one, rarely if ever fails to be beneficial to the rest. Thus, while exercise, adequate clothing, the bath, friction, and cleanliness, are very efficacious in promoting the insensible perspiration, removing the impurities which it leaves behind, and equalizing the circulation, they are almost equally influential in promoting the vital action of the innumerable nervous filaments ramified on the skin, and the tone of which is as essential as that of the blood-vessels to the proper discharge of the cutaneous functions. In the large and afflicting class of nervous and mental diseases, attention to the skin becomes therefore almost a *sine qua non* of successful treatment. As a preservative, too, it is influential. In most nervous ailments, languor and inaction of the skin shew themselves simultaneously with the earliest dawn of mental uneasiness, and often attract notice before the morbid feelings of the mind have acquired either permanence or strength. At this early period, the use of the bath will frequently prove very efficacious in restoring health.

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[*] Sketches of the Medical Topography and Native Diseases of the Gulf of Guinea, p. 101. London, 1849.

Many imagine the tepid and warm bath to be weakening, but experience shews that they are so only when abused. When not too warm, and not prolonged beyond 20 or 30 minutes, the tepid bath may be employed daily with advantage and perfect safety by persons in health; while invalids, whose condition requires its use, are often strengthened by a much longer and equally frequent immersion. I have seen it resorted to for an hour daily, for months in succession, by nervous invalids, with much benefit to health and strength; and on the Continent it is employed to a much greater extent. At some of the German and Swiss watering-places, immersion is continued for many hours, and from the analysis of the water it is evident that the beneficial effects are due principally to the immersion, and little, if at all, to the mineral ingredients contained in it. Thus at the baths of Leuk, in the Vallais, the period of immersion is gradually increased from one hour to eight hours a-day; four before breakfast, and four after dinner. The temperature of the water of the baths is about 96° F., and it contains in 24 ounces about 21 grains of mineral salts, of which about 20 are sulphates of lime and magnesia.* At the vast hospital of Salpêtrière in Paris, and also at Charenton, the late M. Esquirol for many years directed the warm bath to be extensively used for two, three, and even five or six hours a-day —with excellent effect; and recently M. Brierre de Boismont has urged upon the attention of the medical profession the powerful influence of prolonged bathing, in soothing the system in nervous affections without the disadvantage of producing the great debility which so often follows blood-letting. When I visited the hospital for the insane at Charenton, and M. Esquirol's admirable private asylum at Ivry, in September 1831, that distinguished physician spoke to me in very strong terms of the benefits resulting from the practice, and declared that he had ever found it, when used with ordinary prudence, a safe and valuable remedy; and that, in reality, its failure to do good in some cases proceeded more from the patient remaining in it too short a time, than from its want of power to relieve. The benefit which prolonged bathing is thus shewn to produce is probably brought about in various ways. In the first place, it has a direct soothing influence on the nervous system. Secondly, by causing a flow of blood to the surface it at once relieves internal organs, and increases the tone and action of the cutaneous vessels. Lastly, the exhaling and absorbing functions of the skin are probably affected by means of the process of endosmosis and exosmosis, through which some modification of the fluids of the body is produced.

In the *Medico-Chirurgical Review* for January and April 1833, a very interesting outline is given of an article published in the *Revue Médicale*, illustrative of the efficacy of the tepid bath, and the affusion of cooler water on the head during the last few minutes of immersion, in the cure of a variety of nervous and head affections of considerable obstinacy and severity. Dr Johnson, the editor of the Review, adds his testimony to the success of the practice, and the results obtained agree entirely with my own experience; but, as those papers relate to the treatment of *disease*, it would be out of place to do more here than recommend them to the attention of the professional reader. I may mention, however, that Dr Recamier frequently orders the bath to be repeated two, three, or even four times a-day. So little reality is there in its supposed debilitating effect.

I notice these facts to shew that attention to the health of the skin is really as influential in preserving the tone of the nervous system, and in contributing to mental and bodily health and comfort, as, from the important functions which it performs, one would naturally expect it to be; and the neglect with which it has long been treated can be explained only by the ignorance which still prevails regarding its nature and uses. I must add, however, that while I attach so much importance to the use of the bath, the foregoing observations have not been inserted for the purpose of inducing persons in bad health to have recourse to it of their own accord. This they ought never to do, as they may chance to suffer from using it unseasonably. No rules of universal application can be laid down, and this is not the place for a professional disquisition.

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* Encyclopädisches Wörterbuch der Medicinischen Wissenschaften, vol. xxi., p. 396. Berlin, 1839. See also Murray's Handbook of Switzerland, and the 21st chapter of Dr Forbes's Physician's Holiday.

Another valuable means of keeping up an equal circulation and a due degree of perspiration over the whole surface of the skin, and at the same time of aiding in the removal of the impurities which attach to it, consists in the daily and diligent *use of friction by means of a flesh-brush or horse-hair glove*,—the latter to be preferred where the skin is not too sensitive or delicate. But to derive due advantage from friction, it should be steadily continued every night and morning till a glow is excited over the whole surface, and the skin acquires a soft velvety feel. It should also be practised by the individual, and not by an assistant. It then serves partly for exercise, and, to a sedentary person, becomes its most invaluable substitute when perseveringly persisted in for months. In delicate states of the constitution, when a great susceptibility of cold exists, and in all varieties of nervous depression with a dry cold skin, its usefulness can scarcely be overrated. But then it is one of those preservatives or remedies which require time to produce their full effects. It may be weeks before a languid or hysterical female, or hypochondriacal *littérateur*, will be aware of deriving any comfort from its use, and it is consequently sometimes difficult to induce the patient to make a proper trial of it. But I have never known any one, however sceptical at first, continue it regularly and diligently for several months without gratefully acknowledging the benefits which it conferred. I have known, indeed, some cases of severe nervous suffering of many years' standing, in which the relief afforded by friction of the skin was so marked as to elicit from the patients the earnest declaration that no motive could induce them to desist from its use. In rheumatic constitutions, it is especially beneficial; and a clear indication of its usefulness being more and more appreciated, is the frequent announcements of "*electrical*" hair-gloves and other means of friction, in the newspapers of the day.

That friction is useful also in removing impurities from the surface will be evident to every one who chooses to apply a hair-glove to his own skin, after passing a day or two without either friction or ablution. He will then speedily find the glove become whitened from the small powdery scales which it detaches from the epidermis, and experience a very perceptible increase of comfort. From the equalizing action of friction on the circulation and nerves of the skin, it acts farther as a pleasing sedative after mental excitement or anxiety, and thus favours quiet and refreshing sleep, where otherwise none might be obtained.

But it may be said that baths cannot be had at all times and in all places. This may be very true; but although we cannot always command them, it is right that we should know their value, and take active measures to procure them. When we fail, soap and water may still be obtained everywhere, and leave no apology for neglecting the skin; or, as already mentioned, if the constitution be delicate, water and vinegar, water and salt, or mere water by itself, used daily, form an excellent and safe means of cleansing and gently stimulating the skin: to the invalid they are highly beneficial, when the nature of the indisposition does not render them improper. A rough and rather coarse towel is a very useful auxiliary in such ablutions. Few of those who have steadiness enough to keep up the action of the skin by these means, and to avoid strong exciting causes, will ever suffer from colds, sore throats, or similar complaints; while, as a means of restoring health, they are often incalculably serviceable. If one-tenth of the persevering attention and labour bestowed to so much purpose in rubbing down and currying the skins of horses, were bestowed by the human race in keeping themselves in good condition, and if a little attention were paid to diet and clothing,—colds, nervous diseases, and stomach-complaints would cease to form so large an item in the catalogue of human miseries. Man studies the nature of other animals, and adapts his conduct to their constitution; himself alone he continues ignorant of and neglects. He considers himself as a being of a superior order, and not subject to the laws of organization which regulate the functions of the inferior animals; but this conclusion is the result of ignorance and pride, and not a just inference from the premises on which it is ostensibly founded.

The writer of these remarks has, unfortunately for himself, had extensive experience in his own person of the connection between the state of the skin and the general health, and especially the health of the lungs: he can therefore speak with some confidence as to the accuracy of his observations, and the benefit to be derived from attending to the condition of the skin in chronic pulmonary complaints and indigestion. Many affections of a consumptive character are preceded or begin by deficiency of vital action in the skin and extremities, and a consequent feeling of coldness in the feet and on the surface, and susceptibility of catarrhal affections from apparently inadequate causes, often long before any pressing symptom, directly connected with the lungs, occurs to attract notice. In this state, means systematically directed to restoring the cutaneous circulation will frequently be successful in warding off consumption; and even when the disease is formed, the same means will help to prolong life and relieve suffering, while they will go far to effect a cure in those chronic affections of the bronchial membrane, which simulate consumption and are sometimes undistinguishable from it, and which, when mismanaged, are equally fatal.

The two remedies which enjoy the oldest and most general reputation in the successful treatment of pulmonary and consumptive disease and of general bad health, have this quality in common—that both owe much of their influence to their exciting the cutaneous functions, and equalizing the circulation. I allude to *sailing* and *riding on horseback*. Many authors speak of both in the highest terms, and Sydenham is well known to have considered the latter as almost a specific. Dr Rush of Philadelphia, too, extols it with nearly equal force. Of late, a regular course of emetics has been very strongly recommended in the early stages of consumption, and apparently on good grounds. In hooping-cough, chronic catarrh, and other obstinate pulmonary affections, they have also been long in vogue, both with the vulgar and with the profession. So far as my observation goes, all of these remedial means are productive of advantage, chiefly in proportion as they determine the blood to the surface—which squeamishness, sea-sickness, and riding, all do in a powerful manner. Riding seems to have this effect, partly from the bodily exercise giving general vigour to the circulation, and partly from the continued gentle friction between the skin and the clothes stimulating the cutaneous vessels and nerves. This latter effect is of more importance than many may believe. Those, accordingly, who are proof against sea-sickness derive least benefit from a voyage; while those who suffer under it long, are compensated by the amelioration which it induces in the more serious malady. The writer of these pages became ill in the month of January 1820, and soon presented many of the symptoms of pulmonary consumption. In spite of the best advice, he continued losing ground till the month of July, when he went by sea to London, on his way to the south of France; but, finding himself unable for the journey, he was obliged to return from London, also by sea. Being extremely liable to sea-sickness, he was squeamish or sick during the whole of both voyages—so much so as to be in a state of gentle perspiration for a great part of the time. After this he became sensible, for the first time, of a slight improvement in his health and strength, and of a diminution of febrile excitement. Some weeks afterwards, he embarked for the Mediterranean, and encountered a succession of storms for the first four weeks, two of which, in the month of November, were spent in the Bay of Biscay, in a very heavy sea. For more than three weeks he was generally very sick, and always in a state of nausea; and during the whole time, although his bed was repeatedly partially wetted by salt water, and the weather cold, the flow of blood towards the skin was so powerful as to keep it generally warm, always moist, and often wet with perspiration, forced out by reaching and nausea. The result was, that on entering the Mediterranean at the end of a month, and there meeting fine weather, he found himself, though still more reduced in flesh and very weak, in every other respect decidedly improved; and, on his arrival in Italy at the end of seven weeks, recovery fairly commenced, after about ten months' illness: and, by great care, it went on with little interruption, till the summer of 1821, when he returned home.*

To carry on what was so well begun, riding on horseback in the country was resorted to, and that exercise was found to excite the skin so beneficially as to keep it always pleasantly warm, and generally bedewed with moisture, even to the extremities of the toes: and in proportion to this effect was the advantage derived from it in relieving the chest, increasing the strength, and improving the appetite. A second winter was spent in the south with equal benefit; and in the summer of 1822, riding was resumed at home, and the health continued to improve. The excitement given to the skin by riding was sufficient to keep the feet warm, and to prevent even considerable changes of temperature from being felt; and rain was not more regarded, although special attention was of course paid to taking off damp or wet clothes the moment the ride was at an end. Strength increased so much under this plan, combined with sponging, friction, and other means, that it was persevered in through the very severe winter of 1822–3, with the best effects. For nine years thereafter the health continued good, under the usual exposure of professional life; but in 1831 it again gave way, and pulmonary symptoms of a suspicious character once more made their appearance. The same system was pursued, and the same results again followed the invigoration of the cutaneous functions and of the general health by a sea-voyage, horse-back exercise, and the regular use of the bath. These, as formerly, proved beneficial in proportion to their influence in keeping up warmth and moisture of the surface and extremities.

In thus insisting upon the advantages of maintaining the healthy action of the skin, I must not be supposed to ascribe the whole benefit to that circumstance alone. So beautifully is the animal economy constituted, that, as I have already repeatedly had occasion to observe, it is impossible to use rational means for the invigoration of one organ or function, without good being done to all; and so closely are the various parts allied to each other, that, to describe fully the functions and sympathies of any one, we should require to make the circle of the whole. From this appears the error of those who select the derangements of any one organ as the origin and source of all existing diseases. Some functions are no doubt more important, and their disorders exercise a wider influence over the general health, than others; but no one who knows the structure of the human body and the relations of its parts, or has carefully observed the phenomena of disease, can be satisfied with such exclusive reasoning. The stomach, the bowels, the liver, and the nervous system, have each had their patrons, and the derangement of each has been specially held out as the grand fountain of human misery. Each doctrine, too, has been demonstrated by cases and cures to be superior to all the rest, and each has proved successful in its turn, where the others have been tried and failed. Far, however, from proving the propriety of exclusiveness in favour of any one organ, such facts, rightly considered, demonstrate the reverse, and shew that successful practice requires views and remedies founded on a careful examination of *every* function; and afford a strong presumption that the man who traces every disease to the liver, the stomach, or the nerves, will be at least as often strikingly wrong as strikingly right.

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* There were no ocean steam-ships in those days, and these voyages were made in sailing-vessels.

In saying, therefore, that attention to the state of the skin is influential in preserving and restoring health, I wish to represent this as an important but by no means exclusive condition, and to ascribe to the means used for invigorating the cutaneous functions their due share of action upon other organs. Sailing, for example, is useful in pulmonary complaints, not only because its accompanying nausea causes a healthful flow of blood from the internal parts to the surface, but because the gentle and constant exercise, occasioned by the movement of the ship, is admirably adapted to a debilitated state of the system, when other exercise cannot be taken without hurrying the breathing or inducing fatigue—and because pure, fresh, bracing air is of infinite importance in all, and especially in pulmonary affections. Attention to the skin, therefore, must never be considered for a moment as superseding attention to the other functions. That were a pernicious mistake. It must be regarded as a part only, though an important part, of a rational and consistent treatment; and its efficacy will often depend, in no small degree, on the care which is taken to support its effects by a scrupulous attention to the necessities of the rest of the system.

In the healthy state, a quantity of lactic acid is formed in the tissues of the body, as the result of the combination of the oxygen of the air inhaled in respiration, with the tissues of the body and the elements of the food; and this acid must be eliminated by the various organs of excretion, in order that health may be preserved. In this work of elimination, the lungs, skin, and kidneys concur. When *respiration* is active, the lactic acid is converted principally into carbonic acid, and in this shape is excreted by the lungs. When *perspiration*, again, is profuse, it passes off freely by the skin. And when both of these channels are inactive, it becomes abundant in the *urine*. In abnormal conditions, however, when the acid exists in excess in the juices of the body, or when its proper elimination is prevented, the mucous membrane of the stomach and bowels endeavours to assist in its excretion, and hence arise the heartburn and acidity of stomach, to which females and others of sedentary habits are particularly subject. During digestion, particularly of animal food, a certain quantity of acid is withdrawn from the blood to constitute the gastric juice, and on such occasions less acid appears in the excretions. In accordance with this fact, it has been pointed out by Dr H. Bence Jones, that, immediately before a meal, the acidity of the urine is at its highest point, and that it gradually falls as digestion proceeds—again to rise during fasting, when there is no call for the secretion of gastric juice.* In practice

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* On Animal Chemistry in its application to Stomach and Renal Diseases, p. 45. London, 1850.—Chemists are not yet agreed

I have often had occasion to remark the powerful influence which free perspiration has in relieving acidity of the stomach and promoting digestion, and also the fact that acidity is most prevalent when the skin is most inactive; and I have therefore been led to prescribe with advantage the frequent use of the tepid and vapour bath in complaints arising from excess of acid. In harmony with the principle stated, Lord Byron is found noting in his Journal (28th March 1814), that after having, when previously very unwell, "sparred with Jackson *ad sudorem*," he felt "much better in health than for many days;" and remarking that "the more violent the fatigue *the better his spirits for the rest of the day*," and this, too, at a time when he was deriving little relief from his favourite remedies, abstinence and soda-water. On the other hand, I have always heard most complaints of acidity made towards the end of autumn, when the colder weather was beginning to diminish perspiration, and change the balance of the circulation.

Among the external agents which exert a beneficial influence on the health of the skin, there is one of much importance, which, in practice, is far too much lost sight of, and which must yet be obvious to every one on a moment's reflection: I allude to *the salutary stimulus of the solar light*. Those who live in the deep valleys of mountains (as in those of the Alps), in close narrow streets where the sun never shines, in mines or dark caves, and who are rarely exposed to the light of day, present a sallow relaxed condition of the skin, which contrasts with the ruddy freshness of country people and others living much in the sun and open air. The inhabitants of towns, accordingly, may generally be known by the light colour and delicacy of skin which confinement induces. Part of the effect is owing, no doubt, to the agency of the external air, which in confined situations is always more or less loaded with impurities; but much is also attributable to deprivation of the stimulus of light. When plants are deprived of the influence of solar light, their leaves cease to decompose the carbonic acid of the atmosphere; and hence, when kept in the dark, they become pale, watery, and feeble. That the development of animals is likewise influenced by the absence of light appears from the experiments of Edwards, who found that tadpoles when deprived of its stimulus do not undergo the transformation into frogs. In the same way, the development of man is impeded where the free access of solar light is prevented, and here undoubtedly lies one of the chief causes of the excessive infantile mortality in cities. This mortality decreases rapidly as the children grow and are able to run out of doors. The influence of light and the fresh air then begin to counteract the bad effects of their close and dark abodes, and frequently the symptoms of scrofula and rickets are observed to disappear solely in consequence of the beneficial stimulus of pure air and solar light. On the other hand, those who are compelled by circumstances to remain much within doors retain an unhealthy aspect. The functions of the skin, of the lungs, and of the heart, are lowered in tone, and nutrition becomes imperfect. The blood

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as to the precise cause of the acidity of the urine. At one time Lehmann considered it to be due always to lactic acid, but Liebig shewed that it might be owing to acid phosphate of soda. This induced Lehmann to reconsider the matter, and he now thinks that although the acidity may be explained by the presence of the acid phosphate, still the urine generally contains an organic acid. Whether this be lactic acid or hippuric acid, would not disturb the views adopted in the text; for, whatever the nature of this organic acid, it must of course be derived from the metamorphoses which take place in the body; and if not excreted by the kidneys, it must appear elsewhere, though the composition may vary according to the excreting organ. For instance, the carbonic acid of the pulmonary excretion is the result of the oxygenation principally of lactic acid; and consequently, the increase of carbonic acid in this excretion clearly implies the diminution of lactic acid in the excretions of other organs.

ceases to be properly constituted and the countenance is pale and flabby; active disease speedily follows, and an unhappy existence is terminated by early death. But even in cases where no such marked result ensues, and where life is prolonged perhaps to the average term, the evil effects of the deprivation of light are seen in the stunted growth and general deterioration of the race. Of this consequence M. Fourcault gives the following striking example. The inhabitants of the arondissement of Chimay in Belgium, about 3000 in number, are engaged partly as coal-miners, and partly as field-labourers. The latter are tall and robust, and readily supply their proper number of recruits to the army; while among the former it is in most years impossible to find a single man who is not ineligible from deformity or stunted growth.* In like manner, men who work during the night and sleep during the day, never present the vigorous look of health which distinguishes well-fed day-labourers. Hence the necessity which exists, particularly in a climate favoured with so little sunshine as ours, of endeavouring always to select a good exposure to light and air for our dwellings, and of resorting to some protecting legislative measures to prevent that crowding together of low damp cellars and sunless and airless rooms, in which so many thousands of the poorer classes in most of our large towns are compelled to dwell, to the utter sacrifice of every comfort worth living for, and to the positive ruin of both body and mind. In many of the English manufacturing and other towns, a great proportion of the working classes live either in cellars or in courts, which seem as if constructed on purpose to admit the smallest possible portion of air and light by which human existence can be sustained. It was calculated that in Liverpool, till very recently, between thirty and forty thousand people lived in cellars; and the consequences to the health of the community were so serious, that the bold remedy was adopted of declaring such habitations illegal, and ejecting the inmates by the law. In this way, 4700 cellars had, near the end of 1849, been cleared of 20,000 inhabitants. In Edinburgh and Glasgow, thousands of the poor are as badly if not worse lodged, and it is appalling to think of the amount of misery constantly existing around us in this form, sufficient to goad on the minds of its victims almost to madness, when they compare their own lot with that of the richer classes who take so little heed of their suffering, and are often in fact but little aware of its existence. It is fervently to be hoped that the public mind is becoming alive to the perception of the truth, and that the efforts made by the Government will prove to be only the commencement of a series of measures calculated to improve and elevate the condition of the working population, and thus to keep that class of the community from the dangerous expedient of rising in open violence to rectify what is amiss, and seeking by force the means of happiness which they despair of being able to wrest from the sympathy of their fellow-creatures. As yet, however, no general progress has been made, the improvement which has taken place in any single district or town having been more than counterbalanced by retrogression in others. Thus, while such strenuous efforts are being made to eradicate the cellar populations of Liverpool and Manchester, we find another rapidly growing up in Marylebone.* "I have myself," says Mr Grainger, "examined some of these kitchens, as they are termed, and I am bound to say, that in construction and wretchedness they are more objectionable as dwellings than many of the cellars of Liverpool and Manchester, the use of which has been prohibited by the authorities of these towns." Accordingly, if we take the cholera as a test of sanitary improvement, we shall find that the condition of the metropolis is now considerably worse than it was in 1832. There, during the first epidemic, one person died in every 255 of the inhabitants; during the second, the rate was one in 151.

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* Causes Générales des Maladies Chroniques, p. 40. Paris, 1844.

* Appendix B. to Report on Cholera of 1848-9, by Board of Health, p. 60.

The share which *absence of light* has in producing disease, is well illustrated by a fact mentioned by M. Fourcault. His attention was attracted by the mutilated condition of several large mulberry trees, the branches of which, before their mutilation, must have shaded the schoolroom in which a number of orphan girls, affected with chronic maladies, were educated. On asking the reason of the mutilation, he was informed that the shade of the trees visibly increased the severity of the scrofulous affections, and that a very favourable change had taken place in the condition of the girls since the free access of the light of the sun had been permitted.*

The last means of preserving the healthy activity of the cutaneous circulation and exhalation which requires to be noticed, is that of avoiding as much as possible *the contact of noxious external agents*, which might otherwise be absorbed by virtue of the inhaling power of the skin, and thus produce disease.

The chief sources of external agencies of this kind are impurities in the air or locality in which we live; contagious or infectious matter temporarily in contact with the skin; and, lastly, poisonous or injurious substances, such as poisonous metallic vapours to which workmen are exposed in various trades.

A damp locality or air is the most favourable to the absorption of hurtful external agents, because moisture affords a natural stimulus to the action of the absorbent vessels. Hence malaria is always most dangerous after sunset and during the night; and hence also, in some measure at least, the watery phlegmatic constitutions of the inhabitants of marshy and moist districts of country, and the prevalence of ague among them. On the same principle, the operation of dry heat in putting a stop to the diffusion of plague, fever, and dysentery, may be partly explained. The absence of moisture leaves the cutaneous absorbents inactive, while the heat increases the exhalation from the skin. Again, contagion is known to be more likely to take effect on a person who is fasting, than on one who is well fed: partly because in the former state the body is weakened, and has less power to withstand deleterious influences; partly, as we have already observed, because the excretion of the insensible perspiration being at its minimum, the malaria more readily rests upon the surface; and partly because, in the state of fasting, the system craves for a supply, and a readiness to absorb is thus produced—whereas, in the well-fed individual, the system is fortified, and it is *exhalation* that is stimulated. If equal doses of poison be administered to two dogs, one of which has been previously bled, while a quantity of water has been injected into the veins of the other, the poison speedily takes effect in the first, but a considerable interval elapses before symptoms of poisoning appear in the second. In the one, the fluids of the body having been reduced by bleeding, absorption is active; in the other it is sluggish, because the vessels are already full. In the navy, this principle is recognised and acted upon, by never exposing the crews in the morning to the dew and damps of warm climates until after they have breakfasted. "I have been often asked," says the philanthropic Howard, "what precautions I use to preserve myself from infection in the prisons and hospitals I visit? I here answer, once for all, that next to the mercy and goodness of God, temperance and cleanliness are my preservatives. Trusting in Divine Providence, and believing myself in the way of duty, I visit the most noxious cells, and while thus employed, fear no evil. *I never enter an*

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* Causes Générales des Maladies Chroniques, p. 42.

hospital or prison before breakfast, and in an offensive room I never draw my breath deeply."[*] The equal propriety of the last precaution will be made obvious in the chapter on respiration. In fact, Howard may be cited as an example of the practical advantages derivable from physiological knowledge, as in all probability he owed the preservation of his life during years of exposure to the simple suggestions afforded by his early medical education.[†] It is probable that the immunity from plague which is said to be enjoyed by oilmen and others whose skins are more or less covered with oil or grease, arises from the impediment which such a state of the surface presents to the process of absorption being carried on.

When one is obliged to live in a damp, marshy, or malarious district, the means of protection to be used have a direct reference to the functions of the skin. Whatever keeps up a vigorous circulation and healthy perspiration on the surface, and affords least scope for the action of the absorbents, is most certain to prove efficacious. A good nourishing diet, ample exercise, cheerful activity of mind, flannel-clothing frequently changed, friction, and fires, are all ascertained to be beneficial, and all of them operate on this principle. The value of flannel as a protection has been already pointed out in the experience of Captain Murray in the West Indies, and of Sir George Ballingall, Dr Johnson, and others, in the East; and practically the same confidence is shewn by the shepherds of the Roman Campagna and the marshy districts of Greece, who clothe themselves in woolly sheep-skins even at mid-summer.

From what we have said, it will be evident that, when attending on friends who are ill of contagious or infectious diseases, the more we invigorate the other functions of the skin, and the less we stimulate the absorbents, the greater will be our own security. With regard to the protection of workmen from the noxious fumes of metals, dust, and other impurities, it would require a great extent of detail on matters foreign to my present design, to enter upon its discussion here. All that I can add is, that in adopting protective measures, scrupulous regard must be had to the constitution and functions of the skin, if we expect any positive advantage from their adoption.

CHAPTER VI.

NATURE OF THE MUSCULAR SYSTEM.

Having examined the nature and uses of the skin, we may next proceed to consider the important system of organs lying almost immediately under it, namely the MUSCLES, which, although in constant activity during our waking hours, and of indispensable necessity to man in every movement which he makes, are perhaps less familiarly known than almost any other part of the body. As the study of the muscular system involves an exposition of the principles which should regulate exercise, it can scarcely fail to excite the attention of the general reader, and especially of those who, as parents or teachers, are interested in the education of the young.

The muscles are those distinct and compact bundles of fleshy fibres which are found in animals immediately on removing the skin and subjacent fat; and which, although not universally known under their scientific name, are familiar to every one as constituting the red fleshy part of meat.

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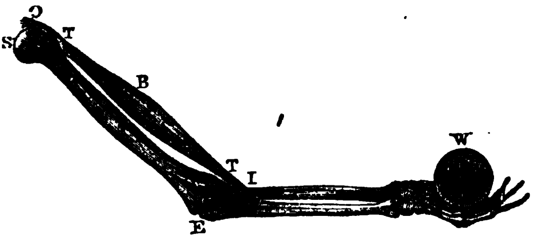
[*] Taylor's Life of Howard, p. 124. London, 1836.

[†] Unfortunately Howard at last caught a fatal fever at Cherson. His earliest biographer, Dr Aikin, expresses some doubt as to the exact nature of the disease, but adds a remark which may serve as a warning to some of our readers. "At any rate," says he, "his disease was certainly attended with debility of the vital powers, and therefore the long and frequent use of James's powders must have been prejudicial. And I think it highly probable that Mr Howard's name may be added to the numerous list of those, whose lives have been sacrificed to the empirical use of a medicine of great activity, and therefore capable of doing much harm as well as good."—Aikin's View of the Character, &c. of Howard, p. 197.

Every muscle, or separate bundle of fleshy substance, is composed of innumerable small fibres or threads, each separated from, and at the same time loosely connected with the others, by a sheath of areolar tissue* enveloping it, but which is so thin as not to obscure the colour of the fibre, or attract notice unless specially looked for. Each muscle, in like manner, is separated from the neighbouring muscles by thicker layers or sheaths of the same tissue, in some of the cells of which fat is deposited, especially where the interval between the muscles is considerable; and hence the elegantly rounded form of the limbs, which, without this fat, would present the rigid, sharp, and prominent outline which we see occasionally in strong persons of a spare habit of body. From the loose texture of the connecting areolar tissue, the muscles enjoy perfect freedom of motion during life, and admit of being easily separated from each other after death, either by the knife, or by simply tearing the areolar tissue.

Muscles, speaking generally, may be divided into three parts, of which the middle fleshy portion, called the belly, is the most conspicuous and important. The two others are the opposite ends, commonly called the *origin* and *insertion* of the muscle. The belly is the bulky and fleshy part, by the contraction or shortening of the fibres of which the two ends are brought nearer to each other, while the belly itself swells out in a lateral direction. When we attempt to lift a heavy weight in the hand, or to overcome any resistance, the muscles which bend the arm may be seen and felt to start out rigid and well-defined in their whole extent, while their extremities tend powerfully to approach each other, and of course to pull along with them the bones to which they are attached. In consequence of this tendency, if a weight be unexpectedly knocked out of the hand, the muscles, having then no resistance to overcome, will contract violently, and throw the hand up with a sudden jerk. Motion is, in fact, effected by the contraction of muscles acting upon and changing the relative positions of the bones or solid framework of the system, and therefore almost all muscles are attached to one bone by their *origin*, and to another by their *insertion;* the former being merely the fixed extremity, towards which the opposite and more moveable end, called the *insertion*, is

Fig. 3.



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* The areolar tissue was formerly usually described as cellular tissue, but this latter designation has of late been pretty generally confined to the elementary cellular structure of the various organs, as shewn by the microscope. The *connecting* tissue under notice was termed cellular, from the interstices or cells contained between its fibres, and the term areolar (from *areola*, a little compartment) is of analogous origin.

carried by the shortening of the intervening belly of the muscle. These points will be readily understood on inspection of Fig. 3, which represents the bones of the arm and hand, having all the soft parts dissected off except one muscle, O B I, of which the function is to bend the arm. O indicates the origin of the muscle; B, the belly; I, the insertion; T T, the tendons; S, the shoulder-joint; E, the elbow. When the belly contracts, the muscle becomes shorter, and the lower extremity of the muscle I is consequently brought nearer to the origin or fixed point O. The arm is thus bent at the elbow-joint, and the weight W raised by the hand.

If the muscles are in general attached to bones, it may be asked,—How can the bones, which present comparatively so small a surface, afford space enough for the attachments of muscles which are so much larger, and which even appear in successive layers above each other? This difficulty is obviated in two ways. In the *first* place, the heads and other parts of bones to which muscles are attached, are enlarged so as to present a greater surface than the body of the bone, and form what are called *processes*, for the express purpose of affording greater room; and, *secondly*, instead of *all* the fleshy fibres of a muscle being prolonged to its point of attachment at the bone, they with a few exceptions terminate gradually, as they proceed from the belly, in a white shining *tendon*, of a much smaller size than the muscle, but of great strength, and which is inserted into the bone. These tendons, or *sinews*, as they are more familiarly named, conduce greatly to symmetry, elegance, and freedom of motion. They may be traced under the skin on the back of the hand, and in the very powerful specimen at the heel, called the tendon of Achilles. The hamstrings are another obvious example, as they may be plainly felt becoming tight when an effort is made to bend the knee. There are a few muscles not attached to bones by either [illegible] and also a few which have no tendons. Those which surround the eyes, the mouth, the gullet, and some of the other natural passages, are of the former description; as is also the heart. Some of the muscles of the trunk have no tendons, but these are so few that they may at present be considered as exceptions to the general rule.

In man, and in most of the animals with which we are familiar, the muscles are of a red colour. This, however, depends entirely on the blood which they contain; for so far is the colour from being essential to their constitution, that it may be destroyed by washing out the blood which produces it, while the muscular substance remains in other respects unchanged. Hence the colour of the muscles depends in a great measure on the quantity and quality of the blood circulating through them. It is dark in game, light in young animals and fowls, and white in fishes. The want of colour in the last "relates to the comparatively small proportion of red blood circulated through the muscular system, and to the smaller proportion of the red particles in the blood of fishes." The bonito and tunny have red muscles from an increased quantity of blood, but "the deep orange colour of the flesh of the salmon and char depends on a peculiar oil diffused through the cellular sheaths of the fibres."* In ultimate chemical constitution, the blood and muscles approach so closely that the former is sometimes called by the French "chair coulante," or liquid flesh. They contain nearly the same proportions of carbon, nitrogen, oxygen, and hydrogen, are of nearly the same specific weight, and the proportion of water which blood contains, very little exceeds that found in muscle. Hence the conversion of blood into muscle would seem to be little else than a re-arrangement of particles.

The true characteristic of muscular fibres is *contractility, or the power of shortening their substance on the appli-*

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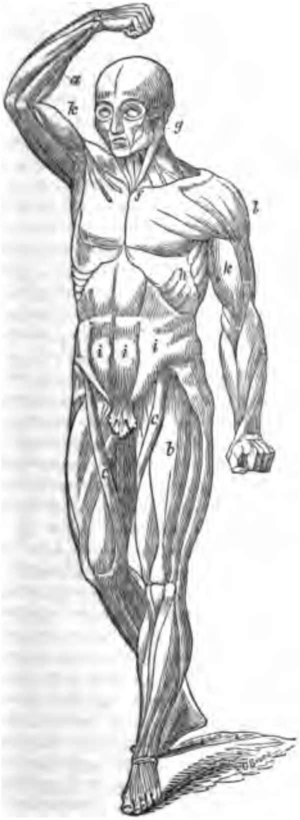
* Owen's Lectures on the Comparative Anatomy of the Vertebrate Animals, vol. i., p. 169.

cation of stimuli, and again relaxing when the stimulus is withdrawn.

Fig. 4.



The muscles of the human body exceed 400 in number, and form several layers lying over each other. That some conception may be formed of their arrangement and distribution, the superficial layer, or that which appears immediately on removing the skin, is represented in Fig. 4, taken from a little volume entitled "The Physician," published by the Society for the Diffusion of Useful Knowledge. To understand the uses of the various muscles, the reader has only to bear in mind that the object of muscular contraction is simply to bring the two ends of the muscle, and the parts to which they are attached, nearer to each other, the more moveable being always carried towards the more fixed point. Thus when the *sterno-mastoid* muscle *f g*, contracts, its extremities approximate, and the head, being the moveable point, is pulled down and turned to one side. This may be easily seen in the living subject, the muscle being not less conspicuous than beautiful in its outline. Again, when the powerful *rectus* or *straight* muscle *b* on the front of the thigh contracts with force, as in the act of kicking, its lower end, attached to the knee-pan and leg, tends to approximate to the upper or more fixed point, and pulls the leg strongly forwards. This occurs also in walking. But when the *sartorius* or tailor's muscle *c* is put in action, its course being oblique, the movement of the leg is no longer in a straight line, but in a cross direction, like that in which tailors move their legs when they sit down to work; and hence the name *sartorius*.

Another variety of effect occurs, when, as in the *rectus* or straight muscle of the belly *i i*, sometimes one end and sometimes both are the fixed points. When the lower end is fixed, the muscle bends the body forward, and pulls down the bones of the chest. When, as more rarely happens, the lower end is the moveable point, the effect is to bring forward and raise the pelvis and inferior extremities; and, when both ends are rendered immoveable, the contraction of the muscle tends to compress and diminish the size of the cavity of the belly, and thus not only assists the natural evacuations, but co-operates in the function of respiration.

In contemplating this arrangement, it is impossible not to be struck with the consummate skill with which every act of every organ is turned to account. When the chest is expanded by a full inspiration, the bowels are pushed downwards and forwards to make way for the lungs; when the air is again expelled, and the cavity of the chest diminished, the very muscles, *i i i*, which effect this by pulling down the ribs, contract upon the bowels also and push them upwards and inwards, as can be plainly perceived by any one who attends to his own breathing. By this contrivance, a gentle and constant impulse is given to the stomach and bowels, which is of great importance to them by propelling their contents and so contributing to digestion; and one cause of the costiveness with which sedentary people are so habitually annoyed, is the diminution of the natural motion of the bowels in consequence of bodily inactivity.

From the preceding exposition, the action of the muscles *a k l*, which bend the arm and the fore-arm, will be easily understood, and some notion may be formed of the innumerable combinations into which a system composed of upwards of 400 pieces may be thrown, in effecting all the movements required from the human frame. In some of the operations in which we engage, nearly the whole, and in others only a few, of the muscles are thrown into action at one time. The simultaneousness of action which obtains in such instances, and which occurs in almost every act of life, however simple, and without which no dictate of the will could be harmoniously and successfully obeyed, depends solely on the distribution and connection of the nerves which animate the muscles. Every individual fibre of every muscle is supplied with nervous filaments, and different fibres of the same muscle are indebted for the simultaneousness of their excitement to the stimulus being conveyed to each of them by filaments of the same nerve. And, in like manner, wherever many muscles combine to execute an important movement, they are uniformly found to be provided with, and connected by, branches from the same system of nerves; as, without this means, simultaneousness of action could not be insured.

From this peculiar constitution of the muscles, it will be obvious that their chief purpose is to enable us to carry into effect the various resolutions and designs—or *volitions*, as they are termed by philosophers,—which have been formed by the mind. The muscles, accordingly, form the grand instruments by which man acts upon the external world, and is acted upon by his fellow-creatures. When the infant clings to its mother's bosom, it does so by calling its little muscles into play. When its cries assail her ear, and alarm her feelings, it is by muscular action they are produced. When she flies to its relief, or lulls it to sleep by some simple chant, her muscles are still the medium by which her sympathy and affection are expressed. Life itself is sustained by the constant exercise of muscular power; and were either the heart or the muscles of respiration to forget their part for a few minutes, existence would be at an end. Without the concurrence of the muscular power, man's grandest conceptions and most energetic resolutions would remain equally unknown and unfulfilled. Without muscular power whereby to communicate with their fellow-men, Shakspeare and Milton would have remained mute as the statues which now represent their bodily form, and the immortal creations of their minds would have been lost to the world for ever. Mind is, no doubt, the high and directing power; but without obedient muscles, ready at a call to minister to its wants, mind would remain isolated in the midst of creation, and could neither speak, nor hear, nor touch. Amid the loss of children and friends, and even amid the wreck of worlds, mind, without muscles to express its feelings, would look on in apparent apathy, even when its affections were torn and its sufferings were intense.

The muscles, then, are the indispensable agents and servants of the mind and will. But we have yet to inquire by what means the will exerts its influence over them. As the mind does not reside in the muscles themselves, something more is evidently required to establish and keep up a communication between the two, and for the production of regulated or voluntary motion. Something is required, at once to excite the muscles to activity, and to direct their contractions. Without this, the muscle itself, though perfect in strength and in structure, would remain inert. Now, this stimulus and guidance are conveyed to it by the *nerves*. As we write, the muscles which move the fingers and guide the pen obviously follow the commands of the will; and the moment the will is withdrawn, they cease to operate. If the will be feeble and undecided, the muscular movements will be equally weak and irresolute; whereas, if the mind be powerfully excited, and the will energetic, strength, rapidity, and decision, will equally characterize all the movements of the body. Under the intense excitement and headlong fury of madness, the muscular action of an otherwise feeble man acquires a force often exceeding all our powers of control.

It will be at once perceived from this description, that in effecting voluntary motion, we must have in operation, 1*st*, The brain, or organ of mind, as the *source of the will; 2dly*, the nerves, which *convey* the intimations of the will to the muscles; and, *3dly*, the muscles themselves, by whose contractile powers motion is *produced*. It will be understood, also, why the number and size of the nerves distributed to a muscle are in proportion, not simply to its volume, but to the variety, frequency, and vivacity of the movements required from it; and why some small muscles employed in many combinations, are therefore supplied with a greater variety of nerves than others double their size, but with more simple functions.

Various attempts have been made to determine the amount of the contractile power of muscular fibre; but, from the very nature of the investigation, the results obtained can be regarded as approximative only. Experiments have also been undertaken with the view of shewing the great advantage possessed by muscular tissue over other substances as a locomotive material. It has been proved, for instance, that a fibre of silk of the thickness of one square millimètre (which, though not muscle, is of animal origin), will support as great a weight as a copper wire of similar thickness, while the silk has the advantage of being nine times specifically lighter.* Such calculations are curious, as shewing the great power of resistance which may be exercised by dead animal fibre; but they afford no data for estimating the contractile power of the living muscle. Valentin found, from experiments on the dead subject, that the tendon of Achilles is capable of supporting more than seven times the weight of the body;† consequently, as the snapping asunder of this tendon by the powerful contraction of its muscle occasionally occurs, we thus obtain some data for an estimate of the surprising contractile power which a muscle under powerful stimulus is capable of exerting. The large and strong thigh-bone has been broken by the muscular struggle of epilepsy.

Other circumstances being equal, muscular power is proportioned to the size of the muscle; but it often happens that great power is required where bulk of muscle would be inconvenient or cumbersome. In such cases, the muscle is supplied with an increased endowment of nervous filaments, which compensate, by the strength of stimulus, for what it wants in bulk of fibre. Many birds, for example, require great muscular power to sustain them in their long and rapid flights through the air, and owe its possession chiefly to the strong stimulus imparted to moderate-sized muscles by large nerves, which add extremely little to their weight; whereas, had the greater power been obtainable only from an augmentation of fleshy fibres, the consequent addition of weight would, from the greatly increased difficulty the animal must have felt in raising and sustaining itself in the air, have gone far to counterbalance any advantage gained on the side of power. But in fishes, which float without effort in their own element, size produces no such inconvenience, and their strength, accordingly, is made to depend more on the volume of the muscle than on its nervous endowment,—shewing a beautiful adaptation of its structure to the mode of life and wants of the animal.

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* Valentin's Lehrbuch, &c., vol. i., p. 31.

† Ibid, p. 34.

Since voluntary motion depends as much on nervous stimulus as on muscular agency, it happens, that whatever interrupts the action of the nerves puts a stop to motion as effectually as if the muscular fibre itself were divided. Injuries and diseases of the brain, whence the will emanates, are well known to be accompanied with palsy, or want of power in the muscles, although in their own structure the latter remain sound. Sleep and narcotics, too, suspend voluntary motion, solely in consequence of their action on the nervous system. Ardent spirits, in like manner, disturb the regularity of muscular action in no other way than by previously disordering the brain; and hence, the unsteady gait and faltering elocution of a semi-intoxicated person are sometimes removed in an instant, by some powerful mental impression being suddenly made, sufficient to restore the brain to its natural state, and thereby to give unity and steadiness to the nervous impulse proceeding from it to the muscles. For the same reason, although the brain and muscles be perfectly sound, yet if the communication between them be impaired or destroyed by the compression or division of the nerves, the muscles cease to act.

The stimulus which causes the muscles to contract, issues from that part of the nervous system which is lodged in the cavity of the spinal column, and which has hence received the name of the spinal cord. But the spinal cord must itself receive a stimulus to cause it to send forth the mandate to the muscles to contract, and this stimulus may be either voluntary or involuntary. The spinal cord constitutes, as it were, a passive instrument, charged with the power which excites the muscles to contraction; and it discharges this power according to the nature of the stimulus brought to bear on it. The spinal cord is a long tract of nervous matter extending from the brain to the region of the loins, and giving off in its course nerves to the various organs and tissues of the body. Sir Charles Bell was the first to shew that these nerves are of compound structure, and contain fibres whose office it is to convey the mandate *from* the spinal cord to the muscles, and other fibres which serve to convey *to* the spinal cord the impressions made on their peripheral extremities. The first are the nerves of motion, the latter the nerves of sensation. These two classes are also sometimes called the *efferent* and *afferent nerves*, from the former carrying a stimulus outwards, and the latter conveying an impression inwards. The spinal cord, then, is at its superior extremity in communication with the brain, and, along the whole extent of its course, with the afferent nerves. From the brain it receives the impression produced by stimuli originating there, and through the afferent nerves the impression of stimuli operating on their peripheral extremities. On the nature of these stimuli it depends whether the resulting movements be voluntary or involuntary. They are voluntary when the stimulus to action is the result of the will; they are involuntary when the stimulus is either emotional, or derived from the impressions made on the peripheral extremities of the nerves of sensation. Hence, involuntary motions may have either a mental or a physical origin; and though in adult man the movements which result from the exercise of the will predominate, there are many which, being the consequences of emotional or mechanical stimuli, no effort of the will enables us to control. A ludicrous idea, for instance, will at times overcome our most strenuous efforts to resist laughter, and no voluntary effort which we can exert will enable us to withstand the tendency to cough, produced by the tickling of the windpipe by a lump of mucus. The irritation in the latter case is conveyed along the sensitive branches of the nerves to the spinal cord, and is there "reflected," as the phrase is, on the motor branches which convey to the muscles the stimulus to contract. That combination of muscular contractions which produces coughing follows, and the offending or stimulating body is expelled. From the "reflection" of the stimulus which thus takes place, the resulting movements have received the name of the *reflex motions;* and we shall in the sequel occasionally make use of this term in contradistinction to the purely voluntary motions, although, in strictness, the expression might be equally applied to movements resulting from the stimulus of the will. As we descend in the scale of animal life, the reflex motions acquire predominance in proportion as the brain is less developed; till at last the motions become entirely automatic, and the animal responds like a mere piece of machinery to the application of appropriate stimuli.

In man, the will exercises, in the healthy state, a certain degree of control over the reflex movements; but in some diseased conditions this controlling power is weakened or totally withdrawn, and the body is then subjected to a variety of involuntary movements, which may arise either, 1*st*, from the irritation of the peripheral extremities of the nerves; 2*dly*, from an abnormally excited condition of the spinal cord itself; or, 3*dly*, as is generally the case, from a combination of both of these causes. This is exemplified in hydrophobia, where the least breath of air, acting as a stimulus on the cutaneous nerves, produces the most fearful convulsions; and in chorea, or St Vitus's Dance, in which the involuntary movements are due chiefly to an abnormally irritable state of the spinal cord, arising apparently from a diseased state of the blood. The following case, extracted from Dr Graves' Clinical Lectures,* is an instance of a severe attack of the latter disease, and will shew how completely the voluntary control of the muscular movements of the body may be lost. "When at its height the disease presented a truly appalling spectacle; every part of the system of voluntary muscles seemed to be affected; all the directing influence of volition ceased, and the muscles everywhere were agitated by sudden, violent, and jerking motions, which constantly and forcibly changed the position of her limbs, throwing her into attitudes the most varied, and succeeding each other with extraordinary rapidity. Her arms were indeed thrown about with such force that it became necessary to cover with blankets and soft padding the sides of the sofa on which she lay, and in spite of this and other precautions her limbs were soon covered with bruises. Her state was truly pitiable; one or two persons were constantly engaged in preventing her rolling off the couch; now and then she sat down suddenly, made an involuntary effort to assume the erect position, and as suddenly flung herself down; meanwhile her limbs were flexed, extended, thrown backwards and forwards with increased rapidity. At one moment her hand would be struck against her head, and at the next passed behind her back. It was almost impossible to keep her covered with clothes, for the constant motion of the limbs often tossed the sheets, blankets, and quilts off together, and not unfrequently even stripped her of her stockings."

Since the muscles which are usually subject to the will may be thus thoroughly withdrawn from its control, it follows that to describe them as "voluntary" in contradistinction to the uniformly "involuntary" muscles is incorrect, their voluntary or involuntary action being entirely dependent on the nature of the stimulus issued to them by the spinal cord. In man it is extremely difficult, if not altogether impossible, to draw a strict line between voluntary and involuntary motion. In the healthy and waking state most of the muscles are undoubtedly under the control of the will whenever we choose to exercise it; but there are times when even the best defined voluntary motions appear to become purely reflex or automatic. Thus, motions acquired at first by voluntary effort may by practice become so habitual, as to be performed mechanically and without our consciousness. For instance, an individual wrapped in thought walks on unconsciously, and the muscles of his legs continue to contract without any special effort of the will. The weary soldier has been known to continue his march asleep; and here it would almost seem as if the contact of the foot with the ground yielded stimulus sufficient to continue the act of progression.

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* Vol. i., p. 533.

From facts like this, and from the light which comparative anatomy throws on the physiology of the nervous system, the conclusion must be drawn, that the part of the nervous centres which produces muscular movements and adapts them to certain ends, is different from the part which thinks and wills. The former part is, in man, generally under the control of the latter, but nevertheless often acts independently of it. Accordingly, while muscular action may be directed by the will when this is excited, it is performed on the impulse of other stimuli, when the thinking and willing portion is wrapped in study or sleep. In both cases, the part of the nervous centres from which the motor power issues is the same; the difference lies merely in the cause which excites the power to action. The cerebro-spinal nervous mass, though composed, as we shall afterwards see, of a congeries of organs, may accordingly here be considered, so far as muscular motion is concerned, as falling into two principal divisions; the superior cerebral, or voluntary and guiding portion,—and the inferior or spinal portion, which produces and combines the automatic movements in obedience to whatever stimulus operates upon it. In this sense the spinal portion of the nervous system includes those portions of the nervous mass which have received from anatomists the name of the *sensory ganglia* and the *medulla oblongata*, and which, from their lying within the cavity of the skull, are generally counted as part of the brain.* The spinal cord, too, though usually spoken of as one organ, is in reality composed of a congeries or string of organs, each forming a centre for the production of nervous power. Hence it is not of equal size throughout, but is largest in those parts which are most called on for a supply of nervous energy. This is the case at its superior extremity, where the nerves of respiration, which are in constant action, are given off; and it is the case also in the cervical and lumbar regions, whence those large nerves issue which supply respectively the upper and lower extremities.

In what manner the voluntary stimulus of the will is conveyed to the spinal nerves, and thence to the muscles, is a problem which physiology has not yet solved. We have no consciousness how it is done. We *will* the movement, and it takes place; but we have no choice in the selection of the instrument.

To those whose attention is for the first time directed to the study of physiology, it may appear improbable that movements adapted to a particular end should be performed independently of the will. But a little consideration will shew that this is the case even in man, though to a much less degree than in the lower animals. The newly-born infant begins to suck as soon as any substance is brought in contact with its lips; and that the combination of muscular movements which produces sucking is purely automatic, and wholly independent of the action of the brain, is at once proved by the fact that it takes place equally in infants born without this portion of the nervous mass. In cases of apoplexy, too, when consciousness is totally destroyed, liquids put into the mouth are swallowed by means of a combination of muscular contractions; and in sleep we see the movements of respiration performed as uninterruptedly as in the waking state. In the lower animals the vital principle is less concentrated in the brain than it is in man; and in them, accordingly, life continues for a longer period after the integrity of the nervous system has been destroyed. A bird that is suddenly decapitated will fly several yards before life is extinct, and, in the celebrated experiment of Flourens, a pigeon which was deprived of the cerebral hemispheres lived for some months, "running when it was pushed, flying when it was thrown into the air, drinking when its beak was plunged into water, swallowing when food was put into its mouth,—but at all other times, when left to itself, appearing like an animal in profound sleep."* If a rude comparison be allowable, we may say that the brain is to the body what the engineer is to a locomotive. Both exercise a controlling power, and determine the movements which are to be executed; but the body and the locomotive are alike capable of executing combined movements, the one without the brain, the other without the engineer. Or the brain may be compared to the rider of a horse, whose volition, in general, guides the animal. But the horse may escape from the control of the rider, as the body occasionally escapes from the control of the brain. "I have known," says Dr Williams," the convulsive motions of a paralysed limb so violent in a hemiplegic patient, that it was necessary every night to fasten it down to the bedstead to enable the patient to get sleep."† In this case all voluntary power over the limb was lost by disease; but the muscles obeyed the uncontrolled stimulus which issued from the spinal cord. We shall return to the consideration of this subject when treating of the anatomy and physiology of the nervous system.

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* See Chap. xii. on the Nervous System.

The spinal cord may be likened to a galvanic battery, charged with nervous power, which it sets free on the application of a stimulus. But to a certain extent this power is always overflowing, and communicates to the whole muscular system a certain degree of permanent contraction, (or *tone*, as it is called), which is very apparent, when the soft and flabby condition of a paralysed limb is compared with the firmness of the muscles of a healthy limb, though not in the state of contraction. It is, so to speak, an exaggerated degree of this tone, which characterizes the firm and involuntary contraction of the sphincter muscle which closes the outlet of the intestinal canal, and which remains in permanent action during life, unless paralysed by disease of the spinal cord. In paralysis of the muscles of one side of the face we see this tonic muscular contraction well exemplified. The muscles of the healthy side, being no longer counteracted by their paralysed antagonists, draw by their involuntary contraction the face of the patient to one side. The distortion thus produced is generally unknown to the sufferer till he sees it in a mirror. It is through the failure of this tonic action, also, that the body, when debilitated by long sickness, sinks off the pillow and slips towards the foot of the bed.

As already observed, the muscular movements in adult man are principally the result of voluntary stimulus; and nothing can be more wonderful than the accuracy with which, in the most delicate movements, this stimulus is adjusted and apportioned to such a variety of parts, especially where practice, or in other words *education*, has rendered the combination of powers easy and certain. Not to dwell upon the many associated muscular actions which are necessary for speech, or the more obvious and graceful movements of dancing, fencing, and riding, we discover, in the management of the hand and fingers by engravers, sculptors, watchmakers, jugglers, and other artists and mechanics, a minute accuracy of muscular adjustment to effect a given end, which is the more surprising the more we consider the complicated means by which it is attained. As an instance of the nice and quick adjustment of muscular action, Valentin* mentions that a violin-player of his acquaintance could, in touching the strings of his instrument, bend the middle finger from 48 to 50 times, and the ring finger from 40 to 45 times in five seconds, producing the exact degree of pressure necessary for bringing out the proper musical tones. But in insects the rapidity of muscular contraction far exceeds this degree, and becomes in fact almost inconceivable. Thus, it has been calculated from the sound produced by the wings of a common fly, that its alar muscles at their utmost speed contract no less than 4000 times in a second.

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* Carpenter's Animal Physiology, p. 356. London, 1848.

† Principles of Medicine, 2d ed., p. 93. London, 1848.

* Lehrbuch, vol. ii., p. 205.

In consequence of the co-operation of both nerve and muscular fibre being required to effect motion, excess of action in each is followed by results peculiar to itself. If the NERVES preponderate, either constitutionally or from over-exercise,—as they are apt to do in highly nervous temperaments,—their excessive irritability renders them liable to be unduly excited by ordinary stimuli; and hence, as in hysteric and nervous females, a proneness to sudden starts, cramps, and convulsions, from causes which would scarcely affect an individual differently constituted. Such persons have little muscular power, except under excitement; they then become capable of great efforts of short duration, but sink proportionally low when the stimulus is past. If, on the other hand, the MUSCLES predominate, as in athletic strong-built men, the nervous system is generally dull and little susceptible of excitement, and the muscles which it animates are consequently little prone to the rapid and vivacious action that accompanies the predominance of the nervous functions. Great strength and capability of bodily labour are then the characteristics.

Great muscular power and intense nervous action are rarely conjoined in the same individual; but, when they do happen to meet, they constitute a perfect genius for muscular exertion, and enable their possessor to perform feats of strength and agility, which appear marvellous to those who are deficient in either condition. The most successful wrestlers and gladiators among the ancients seem to have owed their superiority chiefly to the possession of both endowments in a high degree; and among the moderns, the most remarkable combination of the two qualities is exhibited by some of our harlequins, clowns, rope-dancers, and equestrian performers, and also by those who display their strength and power of equilibrium in balancing wheels, ladders, or other heavy bodies, on the chin; and whose performances require, from the small muscles of the jaw and neck, a force of contraction which, when reduced to calculation, almost exceeds belief. Belzoni combined both conditions in a high degree.

From the general resemblance which characterizes the structure of the different nerves, a similarity in function was long ascribed to them all, and no explanation could be given why one muscle sometimes received filaments from different nervous trunks. Recently, however, the labours of Sir Charles Bell, Mayo, Magendie, Bellingeri, and others, have clearly established that in such cases each nerve serves a distinct purpose, in combining the movements of the particular muscles for particular purposes. The muscles of the face and lower jaw, for instance, receive branches from two motor nerves, the object of the one set being to produce the movements of mastication, and that of the other to produce those muscular contractions on which expression depends.

So uniformly is a separate instrument provided for every additional function, that there were strong *a priori* reasons for concluding that the nerves, although running as single filaments in one sheath, are in reality double, and perform distinct functions. Sir Charles Bell has the merit of this discovery. In his work on the Nervous System, he shews that one set of nervous fibres conveys the mandate from the brain to the muscle, and excites the contraction; while another conveys from the muscle to the brain a peculiar sense of the state or degree of contraction of the muscle, by which we are enabled to judge of the amount of stimulus necessary to accomplish the end desired, and which is obviously an indispensable piece of information to the mind in regulating the movements of the body. Sir Charles has also shewn that many of the sensations supposed to be derived from the sense of touch and the skin, arise from the muscular sense, and are wholly imperceptible to the skin, without the co-operation of muscular contraction.

"The muscles have two nerves," says Sir Charles, "which fact has not hitherto been noticed, because they are commonly bound up together. But whenever the nerves, as about the head, go in a separate course, we find that there is a sensitive nerve and a motor nerve distributed to the muscular fibre, and we have reason to conclude, that those branches of the spinal nerves which go to the muscles, consist of a motor and a sensitive filament.

"It has been supposed hitherto, that the office of a muscular nerve is only to carry out the mandate of the will, and to excite the muscle to action, but this betrays a very inaccurate knowledge of the action of the muscular system; for, before the muscular system can be controlled under the influence of the will, there must be a consciousness or knowledge of the condition of the muscle.

"When we admit that the various conditions of the muscle must be estimated or perceived, in order to be under the due control of the will, the natural question arises, Is that nerve which carries out the mandate of the will capable of conveying, at the same moment, an impression retrograde to the course of that influence which is going from the brain to the muscle? If we had no facts in anatomy to proceed upon, still reason would declare to us that the same filament of a nerve could not convey a motion, of whatever nature that motion may be, whether vibration or motion of spirits, in opposite directions at the same moment of time.

"I find that, to the full operation of the muscular power, two distinct filaments of nerves are necessary, and that a circle is established between the sensorium and the muscle; that one filament or single nerve carries the influence of the will towards the muscle, which nerve has no power to convey an impression backwards to the brain; and that another nerve connects the muscle with the brain, and, acting as a sentient nerve, conveys the impression of the condition of the muscle to the mind, but has no operation in a direction outwards from the brain towards the muscle, and does not therefore excite the muscle, however irritated."*

This consciousness of the state of the muscles—this *muscular sense*, as it may be truly called—is of great importance both to man and to the inferior animals, as it is necessarily by information thence derived, that every subsequent exertion is directed and apportioned in intensity to the effect required to be produced. If we had no such sense, the delicate and well-directed touches of the engraver, painter, and sculptor, or of the ingenious mechanic, would be at the mercy of hazard; and a single disproportioned movement might ruin the successful labour of months, supposing success to be in reality compatible with chance. Without this sense, man could not deliberately proportion the muscular efforts to his real wants; and, even in walking, his gait would be unsteady and insecure, because there would be no harmony between effort and resistance. The loss of equilibrium, and the concussion and disturbance of the system consequent on taking a false step, as it is called, are specimens of what we should always be subject to without the guidance of the muscular sense. When we imagine we have one step more of a stair to descend than really exists, we are placed nearly in the same circumstances as if we had no muscular sense to direct the extent of our intended movement; because, misled by an erroneous belief, we make an effort grievously unsuited to the occasion. And yet so habitually are we protected from this error by the assistance of the sense alluded to, and so little are we conscious of its operation, that it is only after mature reflection that we perceive the necessity of its existence.

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* Bell's Anatomy, seventh edition, vol. ii., p. 372; and also his work on the Nerves.

In chewing our food, in turning the eye towards an object looked at, in raising the hand to the mouth, and, in fact, in every variety of muscular movement which we perform, we are guided by the muscular sense in proportioning the effort to the resistance to be overcome; and, where this harmony is destroyed by disease, the extent of the service rendered us becomes more apparent. The shake of the arm and hand which we see in drunkards, and their consequent incapability of carrying the morsel directly to the mouth, are examples of what would be of daily occurrence, unless we were directed and assisted by a muscular sense.*

Life and the nervous stimulus are essential to muscular power. Separated from the body, and deprived of both, the muscle which formerly contracted with a power equal to 100 pounds, would be torn asunder by a weight of ten. This fact is of itself sufficient to give a pretty correct notion of the extent to which muscular contraction depends on other causes than the mere structure of the fleshy fibres; for that structure continues unaltered for some time after death, and after the nervous communication has been suspended—and yet how feeble comparatively is the power of resistance which the muscle then possesses!

The required movement having been once effected by the nervous impulse stimulating the muscular fibre to contraction, relaxation speedily follows, and is in its turn succeeded by fresh contraction proportioned to the object in view. *Muscular action, therefore, consists properly in alternate contraction and relaxation of the fleshy fibres.* A state of permanent contraction (beyond the tonic contraction already noticed), is both unnatural and impossible; and, accordingly, the most fatiguing muscular employment to which a man can be subjected, is that of remaining immoveable in any given attitude. To an unreflecting person it may seem a very easy and pleasant occupation to stand for half a day in the attitude of an Apollo or a Gladiator, as a model to a statuary; but, on trying it, he will find, to his astonishment, that stone-breaking and the tread-mill are pastimes in comparison. In the one case, the muscles which preserve the attitude are kept incessantly on the strain; while in the other, they enjoy that alternation of motion and rest for which they were destined by Nature. We may easily put the fact to the test, by attempting to hold the arm extended at a right angle to the body for the short space of ten minutes. He whose muscles, if indeed capable of the exertion, do not feel sore with fatigue at the end of that time, may think himself peculiarly fortunate in possessing a powerful constitution.

The principle just stated explains very obviously the weariness, debility, and injury to health, which invariably follow forced confinement to one position or to one limited variety of movement, as is often witnessed in the education of young females. Alternate contraction and relaxation, or, in other words, exercise, of the muscles which support the trunk of the body, is the only means which, according to the Creator's laws, can conduce to muscular development, and by which bodily strength and vigour can be secured. When a muscle is exercised, it receives an increased supply of blood and nervous energy, and in consequence, when the exercise is not continued too long, but alternates with due periods of repose, it acquires increased size, mobility, and strength. But when on the contrary the exercise is excessive, the nervous energy is exhausted and the nutrition of the muscle suffers. Deficient exercise is followed by a like prejudicial effect; for the muscle, when left in repose, receives small supplies of blood and nervous energy, and remains weak and undeveloped. Chossat, in his remarkable experiments on the effects of inanition, made a curious observation which bears directly on this point. Having ascertained that the entire muscular system loses ·423 of its weight during starvation before death ensues, he found that the pectoral muscles (or those which move the wings) of the pigeons which were the subjects of his experiments, lost in proportion about one-third more than the muscular system taken as a whole. "This remarkable difference," says he, "must be due solely to the state of inactivity to which the great pectoral muscles are condemned from the confinement of the birds in their cages; and it follows that the destructive assimilation of the body which results from the privation of food, ensues more readily in those muscles which remain in a state of repose, than in others in which the ordinary movements of the animal keep up the nutritive action, and thus resist the causes of decay."* The powerful influence of exercise on nutrition has also been experimentally shewn by the late Dr John Reid. This able physiologist divided in four frogs the nerves which supply the posterior extremities, and thus isolated them from their connections with the spinal cord. The limbs were of course all paralysed, but the muscles of one of the paralysed limbs of each frog were daily exercised by a weak current of galvanism applied to the cut extremities of the nerve supplying them, while the muscles of the other limb were allowed to remain quiescent. The application of galvanism was continued for two months, at the end of which time the muscles of the exercised limb were found to retain their original size and to contract vigorously, while those of the quiescent limb had shrunk at least to one-half of their former bulk, and presented a marked contrast to those which had been galvanised.† The imperfect nutrition which is thus shewn to result from the want of exercise receives further elucidation from another experiment by Dr Reid. He divided one of the sciatic nerves* of a rabbit, leaving the other intact. One limb was thus paralysed, the other remained in action. At the end of seven weeks the animal was poisoned, and the muscles and bones of the two limbs were removed and carefully weighed; when the muscles of the sound limb were found to weigh 327 grains and those of the paralysed limb 170. The bones of the sound limb weighed 89 grains, and those of the paralysed limb 81. Thus in seven weeks the muscles of the unexercised limbs had lost very nearly half their weight.†

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* Some ingenious speculations on this subject by Mr James Simpson and others will be found in the Phrenological Journal, vols. ix. x. xi. xii.

These examples of the prejudicial influence of deficiency of muscular action on nutrition, will enable the reader now to trace its practical results in the school-room. Instead of promoting exercise, the prevailing system of female education places the muscles, and particularly those of the trunk, under the most unfavourable circumstances, and renders their exercise nearly impossible. Left to its own weight the body would fall to the ground, in obedience to the law of gravitation; in sitting and standing, therefore, as well as in walking, the position is preserved only by active muscular exertion. But if we confine ourselves to one attitude, such as that of sitting erect upon a chair—or, what is still worse, on benches without backs, as is the common practice in schools,—it is obvious that we place the muscles which support the spine and trunk, in the very disadvantageous position of *permanent* instead of *intermittent* contraction; which permanent contraction we have seen to be in reality more fatiguing and debilitating to them than severe labour. This constant state of exertion, moreover, is unaccompanied by any increase of the circulation; so that the muscles in question receive no additional nutritive supplies to support them under the continued strain. No wonder then that girls thus restrained daily for many successive hours invariably suffer—deprived as they are of the sports and exercise after school-hours which strengthen the muscles of boys, and enable them to withstand the oppression. The muscles being thus enfeebled, the girls either lean over insensibly to one side, and thus contract curvature of the spine; or, their weakness being perceived, they are forthwith cased in stiffer and stronger stays—that support being sought for in steel and whalebone, which Nature intended they should obtain from the bones and muscles of their own bodies. The patient, finding the maintenance of an erect carriage (the grand object for which all the suffering is inflicted) thus rendered more easy, at first welcomes the stays, and, like her teacher, fancies them highly useful. Speedily, however, their effects shew them to be the reverse of beneficial. The same want of varied motion, which was the prime cause of the muscular weakness, is still farther aggravated by the tight pressure of the stays interrupting the play of the muscles, and rendering them in a few months more powerless than ever. In spite, however, of weariness and injury, the same system is persevered in; and, during the short time allotted to that nominal exercise, the formal walk, the body is left almost as motionless as before, and only the legs are called into activity. The natural consequences of this treatment are, debility of the body, curvature of the spine, impaired digestion, and, from the diminished tone of all the animal and vital functions, general ill health;—and yet, while we thus set Nature and her laws at defiance, we presume to express surprise at the prevalence of female deformity and disease!

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* Recherches Expérimentales sur l'Inanition, p. 76. Paris, 1843.

† Physiological, Anatomical, and Pathological Researches, p. 11. Edin. 1848.

* The sciatic nerve is that which principally supplies the posterior or inferior extremity.

† Op. cit., p. 10.

It would be easy, were it needful, to prove that the picture here drawn is not overcharged. A single instance, from a note appended by Dr Forbes to an excellent treatise on "Physical Education," by the late Dr Barlow of Bath, will suffice. After copying the programme of a boarding-school for young ladies, which exhibits only one hour's exercise (consisting of a walk, arm in arm, on the high road, *and that only when the weather is fine at the particular hour allotted to it*), in contrast with *nine* hours at school or tasks, and *three and a half* at optional studies or work,—Dr Forbes adds:—"That the practical results of such an astounding regimen are by no means overdrawn in the preceding pages, is sufficiently evinced by the following fact—a fact which, we will venture to say, may be verified by inspection of thousands of boarding-schools in this country. *We lately visited in a large town a boarding-school containing forty girls; and we learnt, on close and accurate inquiry, that there was not one of the girls who had been at the school two years (and the majority had been as long), that was not more or less* CROOKED! Our patient was in this predicament; and we could perceive (what all may perceive who meet that most melancholy of all processions,—a boarding-school of young ladies in their walk) that *all* her companions were pallid, sallow, and listless. We can assert, *on the same authority of personal observation*, and on an extensive scale, that *scarcely a single girl (more especially of the middle classes) that has been at a boarding-school for two or three years returns home with unimpaired health;* and for the truth of the assertion, we may appeal to every candid *father* whose daughters have been placed in this situation."*

The contractile power of a muscle is diminished whenever nutrition suffers, and it would therefore be contrary to all physiological laws to expect that the muscles of those pallid, sallow, and listless girls should be efficient for powerful or prolonged effort. Want of exercise, by impairing the general nutrition of their bodies, has not only diminished the bulk of their muscles, but likewise deteriorated the quality of the blood; so that even the diminished volume of their muscles is imperfectly nourished, while the nervous stimulus is defective or abnormal. Hence proceed many of those hysterical symptoms which are so frequently seen in young women.

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* Cyclopædia of Practical Medicine, article Physical Education, vol. i., p. 698.

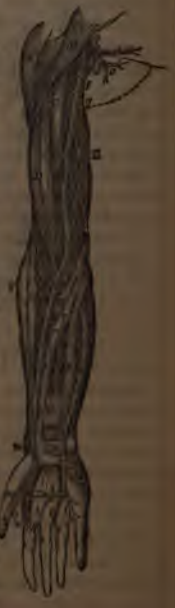
Dr Barlow justly remarks, that the superintendents of boarding-schools cannot generally be blamed for indifference about the welfare of their pupils; that most of them are anxious to do their utmost to improve those under their charge; and that it is *ignorance* alone which misleads them as to the proper means. He might have adverted also to the ignorance of *parents*, who insist on so many hours a-day being dedicated to the acquisition of accomplishments for which their children have neither taste, capacity, nor use. From similar ignorance, the young girls in a public hospital in Scotland used to be *shut up in the hall and school-room during play-hours from November till March, and no romping or noise—in other words, no real play, relaxation, or exercise—allowed*; and in 1830-31, for fear of typhus fever, they were seldom if ever out of doors, except at church from November to April—than which a more efficient system of infringing the laws of health could scarcely have been devised. Here, too, the object was unquestionably benevolent; but the method was radically bad, and, in consequence, a great deal of sickness prevailed.

The reality of the mischief done in this way was forcibly pointed out by the late Mr Carmichael of Dublin, in his excellent "Essay on the Nature of Scrofula," published so long ago as 1810, and which contains many valuable practical truths, which were then little known and coolly received, but to which great importance is now generally attached. In noticing the want of exercise as a cause of scrofula, Mr Carmichael mentions, that in St Thomas's Parochial School in Dublin *seven* out of *twenty-four* girls were affected with that disease during the preceding summer, owing to their exercise having been entirely interrupted, first, by the flooding of the play-ground by heavy rains, and subsequently by the mistress having received orders "*to keep the children perpetually within doors at their school-books.*" In a very short time after "this cruel and impolitic injunction" was acted upon, scrofula began to make its appearance, and afterwards affected nearly a third of their number; although none of them had the disease when admitted, and there was no fault of diet or other cause to which it could be ascribed. Mr Carmichael adds that, in the Bethesda School of the same city, *six* out of *thirty* girls, fed in the best possible manner, and free from the disease on their admission, were badly affected with it during the same summer. In these cases it evidently arose from their having neither yard nor play-ground attached to the institution, in consequence of which "the children were necessitated to remain either in the school or bed-rooms during play-hours." On ascertaining this fact, Mr Carmichael remonstrated with the governors, and the evil no longer exists; but the circumstance itself affords an instructive example of the extent of misery which may arise, not from the institutions of Nature, as we are so apt to affirm, but from sheer ignorance on our own part of what those institutions are.

Mr Carmichael adduces other facts of a striking nature, for which I must refer to his work itself, to shew the needless suffering which is still inflicted on thousands by the sedentary and unvaried occupations which follow each other for hours in succession in many of our schools; and I agree with him that it is high time that a sound physiology should step in to root out all such erroneous and hurtful practices. Taken in connection with the long confinement, the custom of causing the young to sit on benches without any support to the back, and without any variety of motion, cannot be too soon exploded. If the muscles of the spine were strengthened by the exercise which they require, but which is so generally denied,—and if the school employments were varied or interrupted at reasonable intervals, to admit of change of position and of motion—nothing could be better adapted for giving an easy and erect carriage than seats without backs, because the play of the muscles necessary for preserving the erect position would give them activity and vigour;—and, accordingly, the want is scarcely, if at all, felt in *well-managed* infant-schools, for the very reason that such variety of motion is there carefully provided for. But it is a gross misconception to suppose that the same good result will follow the absence of support, when the muscles are weakened by constant straining and want of play. The incessant fidgetty restlessness observable after the second or third hour of common school confinement, shews the earnest call of Nature for a little wholesome exercise: and the quiet that ensues when it is granted, indicates clearly enough that the restlessness springs even more from bodily than from mental weariness. It is, in fact, a degree of what we all feel when kept long standing in one place, or sitting at a desk. We become weary and uneasy from the continued strain on the same muscles, and feel at once relieved by a walk, a drive, or any change whatever. The same principle explains the fatigue so often complained of as experienced in "shopping," or in an exhibition-room. We saunter about till the muscles become sore from the fatigue of being always in the same attitude, and we are refreshed by a walk or a dance, or anything which alters the position. The same langour of the muscles is felt after witnessing a pantomime or other continuous spectacle, by which we are induced to keep the neck for a long time in a constrained and unvaried position. Children with thin bodies, weak muscles, and large heads, sometimes suffer much by being taken to church, and, in order that due respect may be shewn to the sanctity of the place, forbidden by their parents to lean their heads on the board, or on the arm of the person sitting next them, so as to support themselves more easily.

Man being intended for a life of activity, all his functions are constituted by Nature to fit him for this object, and they never go on so successfully as when his external situation is such as to demand the regular exercise of all his organs. It is, accordingly, curious to observe the admirable manner in which each organ is linked in its action and sympathies with the rest. When the muscular system, for example, is duly exercised, increased action in its vessels and nerves takes place; but the effect is not by any means limited to the mere organs of motion. The principal blood-vessels in all parts of the body lie imbedded among muscles, both for the protection and for the aid which the latter afford them. Every contraction of the muscles compresses and lessens the diameter of the vessels; and as the blood contained in them cannot retrograde in its course, it is propelled in the arteries from the heart *towards* the extreme parts, and in the veins *from* the extremities towards the heart, with greater force and velocity than before. This will be better understood on examining the annexed engraving of the blood-vessels of the arm, copied from Fyfe's Anatomy. The letters A, B, C, D, E, represent the principal muscles of the arm, and F, G, H, I, K, L, M, N, those of the fore-arm; though, as the preparation is dried, and the muscles are consequently much shrunk, they do not appear in their natural situations. The letters in italics point out the *humeral* artery, which is seen dividing at the elbow into two branches. The one called the

Fig. 5.



radial artery passes on the outer side of the forearm towards the thumb, and is the branch in which the pulse is generally felt; the other, called the *ulnar*, passes along the inner side of the forearm.

In the natural state, these blood-vessels are covered and protected in almost their whole course by the adjacent muscles. In consequence of this position, the muscles cannot contract without at the same time compressing the blood-vessels, and propelling their contents; for, as mentioned on page 83, the muscles swell out laterally at every contraction. The assistance afforded to the circulation of the blood by this arrangement is familiarly exemplified in the operation of blood-letting from the arm. When the blood stops or flows slowly, it is customary to put a ball or other hard body into the hand of the patient, and desire him to squeeze and turn it round. The utility of this depends on the muscles of the arm compressing the interjacent blood-vessels and forcing onwards the current of the contained blood by their successive contractions, but partly also on the pressure exercised on the deep-lying veins, turning the current into the subcutaneous vessels. Muscular action is, indeed, one of the powers provided for effecting a regular circulation; and hence, when its assistance is neglected, as it is by those who take no active exercise, the blood begins to flow less freely, till at last it finds some difficulty in returning against the law of gravitation from the lower extremities, which then gradually swell. Persons engaged for years in sedentary professions, are thus very subject to *varicose* (or dilated) veins, and swelled feet.

The chain of connection among all the living functions is nowhere more visible than in this relation between muscular exercise and the circulation of the blood. Action requires the presence of arterial blood, and, in the case of the muscles, the very circumstance of their being active favours the circulation and increases the supply. This increase, in its turn, enables the parts to which it is sent to act with greater energy and effect, and the augmented action is attended by corresponding waste and exhalation, and proportionate nutrition of the parts. No vital action, it has already been explained, can take place without being accompanied by certain chemical changes in the solids and fluids of the body; these changes, as they tend to use up the substance of the body, are comprehended under the term *waste*, and their whole products are contained in the various excretions of the body. Now, muscular fibre is composed of about

53	parts of carbon,
7	... hydrogen,
16	... nitrogen, and
24	... oxygen,
100	

along with small quantities of sulphur and phosphorus; and as the kidneys are the chief emunctuories of the nitrogen, the quantity occurring in the urine affords a test of the amount of muscular waste going on in the body. In this fluid it occurs principally as urea, which is composed of

carbon,	20,000
hydrogen,	6,666
nitrogen,	46,667
oxygen,	26,667
	100,000

One part of urea, therefore, contains about three times as much nitrogen as is contained in dry muscular fibre; and, seeing that flesh contains three-fourths of its weight of water, any given weight of urea must represent twelve times that weight of muscular fibre as it exists in the body. Now Lehmann found that, under otherwise similar circumstances, the amount of urea in his urine increased with increase of muscular exercise, from 32 grammes to 36·7 grammes in 24 hours;* equivalent to about 72 grains, and representing an extra waste of 1¾ oz. of muscular fibre. But we know that nitrogen is given off by the kidneys in other forms than as urea, and also in very appreciable quantities by the lungs and skin; hence, the increase of urea can be regarded only as indicating an increase of waste, without in any degree fixing its positive amount.

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* Lehrbuch der Physiologischen Chemie, vol. i., p. 169. Leipzig, 1850.

To replenish the blood exhausted of its nutritive principle by exercise, a greater quantity of food is required; and, to prompt us to attend to this condition, the appetite becomes keener and more imperative, and the power of digestion proportionally vigorous. The food taken is more speedily digested, and its absorption from the surface of the intestines and transmission into the circulating current are more rapid. That the blood so improved may be properly and quickly animalised in the laboratory of the lungs, respiration becomes deeper and more frequent, thus admitting a larger quantity of air and freer circulation through them than before; and the blood, in this way renewed and re-endowed with the pabulum of life, imparts fresh nutriment and vigour to all the organs of the body, and fits them for that active exertion which the proper discharge of his duties imperatively requires from every member of the human race.

Considered in this point of view, the hurried breathing and quickened circulation, of which we are so apt to complain when engaged in muscular exercise, instead of being evils, are, in fact, the beneficent means by which we become fitted to continue the exertion. Without a more than usually rapid flow of blood to the part in use, the necessary stimulus to its vessels and nerves could not take place, and its action could not be sustained. And were not respiration accelerated, so as to oxygenate the venous blood more quickly as it arrived at the lungs, it is obvious that the requisite stimulus must again have failed; as, in that case, the blood must either have accumulated in the lungs and caused death, or have passed through them imperfectly prepared, and extinguished life more slowly, but not less certainly. In the crab and other crustacea we find this relation between respiration and muscular movement even more direct. In them the respiratory cavity is incapable of either expansion or contraction, but consists of a hollow space, with an anterior and posterior aperture, through which the water passes for the purpose of oxygenating the blood in the gills. The water enters by the posterior aperture, driven in by lamelliform appendages attached to the ambulatory or natatory legs, and issues by the anterior aperture. The quantity of water which passes is thus dependent on the activity of the movements of these limbs. Accordingly, the more active the progress of the crustacean, the more briskly will its respiration proceed, from the muscular and respiratory functions being brought into direct relation by this simple connection of their respective instruments.* Along with the increased consumption of material which attends muscular exercise, an increased development of heat, as already observed, always takes place. This point has received direct elucidation from the experiments of Breschet and Becquerel, who shewed that sawing wood for five minutes raised the temperature of the biceps muscle of the arm 1·8° F. Dr John Davy, too, has directly proved that exercise increases the temperature of the whole body—a fact indicated by the increased temperature of the urine voided after a smart walk. Moreover, we obtain evidence that these results are really dependent on chemical metamorphoses, in the circumstance pointed out by M. Du Bois Reymond, that the galvanometer responds to the changes which accompany voluntary contraction of the muscles.†

It is from the effect of muscular compression, noticed above, in promoting the flow of blood through the arteries and veins, that *shampooing*, which consists in a kind of kneading of the flesh, is so successfully resorted to in the warm climates of the East, and among the richer class of invalids in our own country, as a partial substitute for active exercise. Shampooing furnishes from without that impulse to the circulation which the Creator has destined it to receive from active muscular exertion; and the principle of its action being the same, we cannot wonder that it should prove indisputably useful in promoting circulation, strength, and nutrition, in cases where active exercise cannot be enjoyed. Hence also its utility in dispersing indolent swellings, in restoring tone to weakened joints, and in cure of rheumatism.

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* Owen's Lectures on the Invertebrate Animals, p. 182.

† Annales de Chimie et de Physique, 3d series, vol. xxx., p. 127.

It is a common observation, that sedentary persons are habitually subject to costiveness and its attendant evils. The reason is the same. In the natural state, the contents of the bowels are propelled partly by the successive contractions of the muscles which form the walls of the belly and separate that cavity from the chest, and partly by the contraction of the muscular fibres which constitute an important part of the structure of the intestines themselves. If, however, exercise be refrained from, and the same position be preserved for many hours a-day, as in sitting at a desk, the contents of the bowels are necessarily deprived of one important propelling power, and do not move onwards with the same regularity as when exercise is taken. The slowness of intestinal action which ensues can be overcome by no course of medicine, and scarcely any modification of diet, so long as sedentary habits are indulged in; though it may often be relieved by daily pressing over the region of the abdomen with a kind of kneading motion, imitating, though feebly, the effects of muscular action. Females suffer much from costiveness produced by sedentary habits.*

The evils arising from *deficiency* of exercise to all the functions of the mind and body will now be equally evident and intelligible, for they are the reverse of what we have seen to be the advantages of adequate exercise. The circulation, for want of stimulus, becomes languid, especially in the extreme vessels; the feebleness of action occasions little waste of materials, and little demand for a new supply; the appetite and digestion consequently become weak; respiration heavy and imperfect; and the blood so ill-conditioned that, when distributed through the body, it proves inadequate to supply the stimulus requisite for healthy and vigorous action. The concatenation of causes and consequences thus exhibited, cannot fail, when the principle connecting them is perceived, to interest and instruct every thinking mind.

CHAPTER VII.

RULES FOR MUSCULAR EXERCISE.

The laws and conditions of healthy muscular action having now been sufficiently explained, I shall next endeavour to shew how usefully our knowledge of them may be applied to the proper regulation of exercise in the ordinary conduct of life.

In attempting to lay down rules for exercise, our aim should always be to recommend what is in accordance with the physiological constitution of the muscular system. With this principle to guide us, and keeping in view the conditions of muscular action as explained in the preceding chapter, we can have no difficulty in perceiving, that, to derive proper advantage from exercise, it is necessary, 1*st*, that it should spring from, and be continued under, the influence of an active nervous or mental stimulus; 2*dly*, that it should always involve as much variety of movement as possible; 3*dly*, that it should be proportioned to the age, strength, and constitution; 4*thly*, that it should be taken at the most favourable times of the day; and, lastly, that it should be of a kind calculated to ensure all the good effects which well-conducted exercise is capable of affording.

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* See the author's treatise on Digestion and Diet, chapter xv., "On the proper regulation of the bowels."

That *exercise should always spring from, and be continued under, the influence of an active and harmonious nervous and mental stimulus,* will scarcely require any additional evidence; but as the principle is not sufficiently appreciated or acted upon, a few remarks seem still to be called for to enforce its observance. The simple fact that the muscles are expressly constructed for the purpose of fulfilling the commands of the nervous system, might of itself lead to the inference that a healthy mental stimulus ought to be considered an essential condition or accompaniment of exercise; and might render us prompt to observe how easy and pleasant muscular action becomes under the influence of mental excitement, how useful a vigorous nervous impulse is in sustaining and directing it, and how difficult, wearisome, and inefficient it becomes, when the mind which directs it is languid or absorbed by other employments. Hence the superiority, as exercises for the young, of social and inspiriting games which, by their joyous and boisterous mirth, call forth the requisite nervous stimulus to put the muscles into vigorous and varied action; and hence the utter inefficiency of the dull and monotonous daily walk which sets all physiological conditions at defiance, and which, in so many schools, is made to supersede the exercise which it only counterfeits. Even the playful gamboling and varied movements which are so characteristic of the young of all animals, man not excepted, and which are at once so pleasing and attractive, might have taught us that activity of feeling and affection, and sprightliness of mind, are intended by Nature to be the sources and accompaniments of healthful and invigorating muscular exercise; and that the system of bodily confinement and mental cultivation now so much in vogue, is calculated to inflict lasting injury on all who are subjected to its restraints. The buoyancy of spirit and comparative independence enjoyed by boys when out of school prevent them from suffering under it so much as girls do; but the mischief done to both is the more unpardonable when it does occur, because it might so easily have been entirely avoided. Even in some infant schools, where properly conducted exercise ought to be considered as a necessary of life, the principle on which I am insisting is so little understood or valued, that no playgrounds have been provided, and the very best means of moral as well as physical training—play with companions—has, to the great injury of the poor children, been wholly omitted. Under judicious direction, the playground affords the most valuable and effective aid to the parent and teacher, not only in eliciting the highest degree of physical health, but in developing the general character by the practical inculcation of moral principle, kindness, and affection, in the daily and hourly conduct of the children committed to their charge. The following table by Friedländer,* is worthy of attention, and may serve as a general guide for the distribution of the time of children over their various occupations, though we are far from offering it as a standard for universal application. It shows that he attaches even more weight to the due cultivation of the muscular system in childhood and early youth, than to that of the nervous system; and his views are founded on a sound physiology, for each system in the body should be cultivated in accordance with its development. In man the brain is of slow and gradual growth, and a too early taxing of its powers, instead of giving it energy and strength, prevents its ultimate development, and retains in a station of mediocrity many who otherwise might have risen to distinction. Friedländer's division of the day is as follows, according to different ages:—

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* Levy's Hygiène, vol. ii., p. 468.

Ages.	Sleep.	Exercise and out-door occupations.	In-door occupations.	Meals and rest.
7	9	9	2	4
8	9	9	2	4
9	9	8	3	4
10	8	8	4	4
11	8	7	5	4
12	8	6	6	4
13	8	5	7	4
14	7	5	8	4
15	7	4	9	4

This division ought not, however, to be regarded as a rule universally, or even generally, applicable. It errs in giving too little time to sleep, and too much to in-door occupations, especially in the later years; and in estimating it, the reader will bear in mind that the hours of exercise and out-door occupations are proposed to be spent, not in continued muscular exertion, but in a manner which will combine play and recreation with useful employment.

These hours of exercise and recreation may, by a judicious teacher, be made as conducive to the proper training of the young as the time spent on the benches of the school-room; and, instead of being time "wasted," it may be made time most profitably spent for both body and mind.

Facts illustrative of the beneficial influence of a mental stimulus as the only legitimate source of muscular activity abound everywhere, and must be familiar to every reflecting mind; but as the practical inferences deducible from them have, to a great extent, escaped the notice of parents and teachers, I shall add a few remarks in farther elucidation of them.

Every body knows how wearisome and disagreeable it is to saunter along, without having some object to attain; and how listless and unprofitable a walk taken against the inclination and merely for exercise is, compared to the same exertion made in pursuit of an object on which we are intent. The difference is simply, that, in the former case, the muscles are obliged to work without that full nervous impulse which Nature has decreed to be essential to their healthy and energetic action; and that, in the latter, the nervous impulse is in full and harmonious operation. The great superiority of active sports, botanical and geological excursions, gardening, and turning, as means of exercise, over mere monotonous movements, is referable to the same principle. Every kind of youthful play and mechanical operation interests and excites the mind, as well as occupies the body; and by thus placing the muscles in the best position for wholesome and beneficial exertion, enables them to act without fatigue, for a length of time which, if occupied in mere walking for exercise, would utterly exhaust their powers.

The elastic spring, bright eye, and cheerful glow of beings thus excited, form a perfect contrast to the spiritless aspect of many of our boarding-school processions of girls; and the results in point of health and activity are not less different. So influential, indeed, is the nervous stimulus, that examples have occurred of strong mental emotions having instantaneously given life and vigour to paralytic limbs. Thus, Dr Williams tells us that "a lady who for several years had lost the use of her lower extremities, was startled by a rat running near her: having an extreme antipathy to the animal, she made an effort and sprung upon a table near; the power, however, did not remain, for she could not get down again.*

* Such cases may be explained by supposing that that part of brain which gives the feeling of fear—the phrenological organ of Cautiousness—was here violently excited, and that the excitement was directly transmitted to the spinal cord, and communicated to the motor apparatus. So soon, however, as safety was attained the stimulus was withdrawn, and the paralytic condition returned. It is evident that it was not the will which produced motion; because volition was found incapable of overcoming the paralysis, so soon as the excitement was withdrawn. A little reflection will shew how the excitement of the cerebral organs must thus add to the energy of voluntary motion, an effect abundantly exemplified in the text of

A more permanent cure of impaired action," he continues, "has been effected by the excitement of religious fanaticism, as in the case of the supposed miracles of Prince Hohenlohe, Miss Fancourt, &c. As we have found that such mental excitement sometimes causes excessive voluntary motion in healthy persons, so we perceive that, suddenly applied, it may restore it when defective."† Many who feel ready to drop from fatigue after a merely mechanical walk, would have no difficulty in afterwards undergoing much continuous exertion in active play or in dancing; and it is absurd, therefore, to say that exercise is not beneficial, when in reality proper exercise has not been tried.

The amount of bodily exertion of which soldiers are capable, is well known to be prodigiously increased by the mental stimulus of pursuit, of fighting, or of victory. In the retreat of the French from Moscow, for example, when no enemy was near, the soldiers became depressed in courage and enfeebled in body, and nearly sank to the earth through exhaustion and cold; but no sooner did the report of the Russian guns sound in their ears, or the gleam of hostile bayonets flash in their eyes, than new life seemed to pervade them, and they wielded powerfully the arms which, a few moments before, they could scarcely drag along the ground. No sooner, however, was the enemy repulsed, and the nervous stimulus which animated their muscles withdrawn, than their feebleness returned. Dr Sparrman, in like manner, after describing the fatigue and exhaustion which he and his party endured in their travels at the Cape, adds,—"Yet, what even now appears to me a matter of wonder is, that *as soon as we got a glimpse of the game, all this languor left us in an instant.*" On the principle above stated, this result is perfectly natural, and in strict harmony with what we observe in sportsmen, cricketers, golfers, skaters, and others, who, under the influence of agreeable mental excitement, are able to undergo a much greater amount of bodily labour than men of stronger muscular frames, but animated by no such stimulus, or nervous impulse. Intense nervous stimulus becomes the substitute for bulk of muscle, and Sir Walter Scott shewed his knowledge of this physiological truth, when he made the strongly-built form of Balfour of Burleigh fall under the blow of the comparatively slight but nervous arm of Claverhouse, in the retreat after the battle of Drumclog. I have heard an intelligent engineer remark the astonishment often felt by country people, at finding him and his town companions, although more slightly made, withstand the fatigues and exposure of a day's surveying better than themselves; but, said he, "they overlooked the fact that our employment gives to the mind, as well as to the body, a stimulus which they were entirely without, as their only object was to afford us bodily aid, when required, in dragging the chains or carrying our instruments."—In the same way, the conversation of a friend greatly increases the power of walking.

The same important principle was implied in the advice which the Spectator tells us was given by a physician to one of the eastern kings, when he brought him a racket, and told him that the remedy was concealed in the handle, and could act upon him only by passing into the palms of his hands when engaged in playing with it—and that as soon as perspiration was induced, he might desist for the time, as that would be a proof of the medicine being received into the general system. The effect, we are told, was marvellous; and, looking to the principle just stated, to the cheerful nervous stimulus arising from the confident expectation of a cure, and to the consequent advantage of exercise thus judiciously managed, we perceive that the fable is in perfect accordance with nature.

The story of an Englishman who conceived himself so ill as to be un-

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the present chapter. This subject will be more fully entered upon when we come to treat of the nervous system.

† Principles of Medicine, 2d ed., p. 90.

able to stir, but who was prevailed upon by his medical advisers to go down from London to consult an eminent physician who, they told him, resided at Inverness, may serve as another illustration. The stimulus of expecting the means of cure from the northern luminary, was sufficient to enable the patient not only to bear, but to reap benefit from the exertion of making the journey down; and his wrath at finding no such person at Inverness, and perceiving that he had been tricked, sustained him in returning, so that on his arrival at home he was nearly cured. Hence also the superiority of battledoor and shuttlecock, and similar games, which require society and some mental stimulus, over listless exercise. It is in fact a positive misnomer to call a solemn procession *exercise*. Nature will not be cheated; and the healthful results of complete cheerful exertion will never be obtained where the nervous impulse which animates the muscles is denied.

"What is it," asks Mr Wilson, "that makes the difference between the exercise of youth, and that of the felon on the tread-wheel; between the pedestrian in the Isle of Wight or Switzerland, and the pedestrian from Chelsea to the Bank; between the light and quick footstep wending to Greenwich Park, and the dull tread of the nursery-maid at home? Is it not mind? Is it not the young and buoyant joy of the school-boy that inspirits his laugh and his leap? while silent and morose, humiliated, not convinced, the felon suffers his monotonous existence, moving, it is true, but not in exercise. Is it not the novelty or the beauty of the scene, the pleasant weather, or the immunity from customary labour, that gives spirit to the pedestrian's tour, as compared with the dull, desultory repetition of the same sights, same persons, same things, and same path to and from business? Is it not the prospect of enjoyment, of gaiety, or pleasure, that makes the difference between the elastic step of the maiden enfranchised from present duties, and the same person in the pursuit of her necessity-impelled and ordinary offices? We need not ask which is most calculated to be beneficial to health; which to arouse the dormant functions of the skin, to promote the removal of irritating elements from the blood, to increase the vigour of the frame, purify the complexion, and enrich the beaming tints of beauty. In mind lies the great secret of *beneficial exercise*, and without it, exercise is a misnomer, and a fraud on the constitution." *

It must not, however, be supposed, that a walk simply for the sake of exercise can never be beneficial. If a person be thoroughly satisfied that exercise is requisite, and perfectly *willing*, or rather desirous, to obey the call which demands it, he is from that very circumstance in a fit state for deriving benefit from it, because the *desire* then becomes a sufficient nervous impulse, and one in perfect harmony with the muscular action. It is only where a person goes to walk, either from a sense of duty or at the command of another, but against his own inclination, that exercise is comparatively useless. Besides, as already repeatedly observed, exercise, in order to exert a beneficial influence on the whole organism, must be such as to stimulate the circulation and the function of respiration, and, consequently, those changes of matter on which vitality depends. Now, as Valentin has shewn that mere sauntering exercise does not increase the cutaneous exhalations, it follows that no impetus can thus be given to the processes of transformation by which vital energy is generated. No additional quantity of oxygen is inhaled, no increase of animal heat is produced, the circulation is not stimulated, and no glow pervades the surface. The body, therefore, is not fortified against the influence of the weather; and hence it is that delicate females so frequently suffer from "taking a walk" in cold weather. On the other hand, the observations of Vierordt teach us that the beneficial effects of exercise are not limited to the time during which the exercise is taken, but that a stimulus is given to the vital metamorphoses, which continues for a considerable period. Accordingly, every one must have remarked how readily sharp exercise dispels a feeling of chilliness, and imparts an enduring comfortable glow. Vierordt has proved the reality of the stimulus by showing that the lungs continue to excrete about 16·4 cubic inches of carbonic acid more per minute, for a considerable time after a smart walk, and long after all acceleration of the pulse and respiration has ceased, than at other times when the state of quiescence has not been broken.*

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* Wilson on Healthy Skin, 3d ed., p. 116.

The fact that a mental impulse is required to direct and excite muscular action, points to the propriety of teaching the young to observe and examine the qualities and arrangements of external objects. The most pleasing and healthful exercise may be thus secured, and every step be made to add to useful knowledge and to individual enjoyment. The botanist, the geologist, and the natural historian, experience pleasures in their walks and rambles, of which, from disuse of their eyes and observing powers, the multitude are deprived. This truth is acted upon by many teachers in Germany. In our own country, too, it is beginning to be felt, and one of the professed objects of infant-education is to correct the omission. It must not, however, be supposed that *any* kind of mental activity will give the necessary stimulus to muscular action, and that, in walking, it will do equally well to read a book or carry on a train of abstract thinking, as to seek the necessary nervous stimulus in picking up plants, hammering rocks, or engaging in games. This were a great mistake; for in such cases the nervous impulse is *opposed* rather than favourable to muscular action. Ready and pleasant mental activity, like that which accompanies easy conversation with a friend, is indeed beneficial by diffusing a gentle stimulus over the nervous system; and it may be laid down as a general rule that any agreeable employment of an inspiriting and active kind, and which does not absorb the mind, adds to the advantages of muscular exercise. But wherever the mind is engaged in reading or in abstract speculation, the nervous energy is as it were divided, and the muscles are deprived of their due share, by reason of the great exhaustion of it by the brain; the stimulus to set them in motion is proportionally weakened, and their action is reduced to that inanimate kind I have already condemned as almost useless. From this exposition, the reader will be able to appreciate the hurtfulness of the practice in many boarding-schools, of sending out the girls to walk with a book in their hands, and even obliging them to learn by heart while in the act of walking. It would be difficult, indeed, to invent a method by which the ends in view could be more completely defeated as regards both mind and body. The very effort of fixing the eye on the printed page when in motion, strains the attention, impedes the act of breathing, distracts the nervous influence, and thus deprives the exercise of all its advantages. We have already seen how necessary nervous stimulus is to nutrition, and we can now more thoroughly appreciate the magnitude of the evils which result, perhaps, more from its misapplication than from its absence. For true and beneficial exercise, there must, in cases where the mind is seriously occupied, be *harmony of action between the mind which impels, and the part which obeys and acts. The will and the muscles must be both directed to the same end and at the same time*, otherwise the effect will be imperfect. But in reading during exercise, this can never be the case. The force exerted by strong muscles, animated by strong nervous impulse or will, is prodigiously greater than when the impulse is weak or discordant; and as man was made not to do two things at once, but to direct his whole powers to one thing at a time, he has ever excelled most when he has followed this law of his nature.

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* Wagner's Handwörterbuch der Physiologie. Band iv., p. 90.

The second rule for the management of exercise is, that *it should involve as much variety of movement as possible*, for the double purpose of calling into play the greatest possible number of the muscles, and of fulfilling the law which requires their alternate contraction and relaxation as the condition of their well-being. The absolute necessity of attention to this rule will be apparent when we consider that the sphere of action of each muscle is strictly local, and that it is only by calling them all into play that a *general* effect can be produced. Thus, by much walking, we may greatly develope the muscles of the legs, and yet leave those of the arms and chest comparatively feeble; or, by wielding a ponderous hammer, or rowing a boat, we may greatly develope those of the chest and arms, and leave the legs weak, and their circulation languid. For the same reason, a slow formal walk, with demure look and motionless arms, is much less useful than a smart walk or run, in which we cannot refrain from exercising the arms and chest also. In the former case, the influence is entirely confined to the legs, and is small even on them; while, from the trunk and arms remaining rigid and inactive, and the circulation and respiration receiving no stimulus, no *general* advantage is obtained. Exercise, therefore, is most beneficial when all the muscles are called into play; but the exercise of any set of muscles, which is accompanied by general excitement of the system, is much to be preferred to a languid saunter, which leaves the various organs in a state of quiescence.

Another reason for varied movements in exercise is, that the constitution of the muscles requires their frequent contraction and relaxation; and if this is neglected, and they are kept long in the same state of tension, they become wearied and weakened by exhaustion. Let this physiological law be kept in view, and then let the reader consider the motionless attitudes required of the young for hours together in schools and at home, and say whether any plan more opposed to the intentions of the Creator could be devised for their management! When we thus sow the seeds of bad health and physical deformity, have we any right to be surprised and grieved when the crop which we have cherished arrives at maturity? God has kindly laid the conditions of our welfare before us without mystery and without obscurity. If we prefer our own way to that which He in his wisdom has marked out for our guidance, can we, without presumption, complain of the consequences? The path of duty is obvious as the sun at noonday. The human body is composed of bones and muscles in addition to other organs. These bones and muscles, exceeding together six hundred in number, were made expressly for active use; and their health and that of the body depend on this condition being fulfilled, by all of them being called into play by varied and vigorous movements, with proper intervals of repose. But if we reject this variety, and restrict the body to the constrained observance of certain attitudes and motions, a few of the muscles will suffer from being overstrained, but the great majority of them and the bones will become weakened from inactivity, and impaired health and debility necessarily follow.

The principle of varied exercise is often transgressed to an injurious extent among the manufacturing classes, and its results are seen in their impaired physical condition. We are constantly told that the working of young children in factories for eight or ten hours a-day is not hurtful in any degree, because the labour is so light as not to fatigue them. But a statuary might, on nearly the same grounds, assure his living model, when requested to stand for hours in the same attitude, that his doing so cannot fatigue him, as no active exertion is required of him. When we recollect that to preserve the same attitude, the same muscles must be in a constant state of tension, and the remainder in a constant state of relaxation, and that all of them are thus denied that *alternate contraction and relaxation*, and those intervals of repose, which are so essential to their well-being, the case of the factory-children assumes a far more serious aspect. And, accordingly, we know, from indisputable evidence, that the factory system has, notwithstanding the boasted lightness of the labour, produced a large amount of impaired health and physical deformity. In England there are no statistical data of a sufficiently precise or trustworthy character to be adduced as evidence; but it is otherwise in France, where the system of examining the yearly levy of conscripts affords an excellent test, as it shews the exact proportions found unfit for the army, from physical deformity, in every part of the country. All the young men above twenty years of age, liable to serve, are examined one by one with the greatest care by a council composed one-half of military men, and the other half of civilians; and the following are the results of a comparison made between ten departments which are principally agricultural, with ten which are principally engaged in manufactures. "For every 10,000 young men capable of supporting the fatigues of military service, the ten agricultural departments give only 4029 infirm or deformed persons; while the ten departments which are chiefly manufacturing give 9930 (more than double the number) of infirm or deformed persons. These numbers are the *averages* of the ten departments." But this is not the worst of the picture. In the department of the Eure, the proportion of infirm and deformed persons rises so high as 14,451 for every 10,000 capable persons; and according to Baron Charles Dupin, in a speech reported in the *Moniteur* of March 7, 1840, "the fearful consequences that arise from excessive labour in childhood and youth may be judged of from the following facts. In Normandy, for every 100 men strong enough to be passed as recruits for the army, there were rejected 170 young men of twenty years of age at Rouen, 200 at Elbeuf, and 500 at Bolbec, all manufacturing towns!"* Well may it be added in the report, that "such immense disproportions ought not to be looked upon with indifference by the legislature; they are proofs of deep and grievous wounds; they shew that there must be individual suffering of the most afflicting kind. . . . . *We should blush for the state of our agriculture if we could only rear for its operations so small a proportion of oxen and horses able to work, in comparison of so large a number of weak and misshapen animals.*"

I am quite aware that the wholesome regulations now in force in this country, prevent the production of an equal extent of deformity and bad health in our factories; and that in many mills the most active measures are employed to diminish the evils of the system: but it is nevertheless certain that in the best of them the mischief is only mitigated and not extinguished, while in by far the greater number the amount of injury inflicted is still very great. A humane and active spirit of inquiry has, however, been excited, and the general sympathy which it has called forth gives a promise that much more will yet be done to improve the physical and moral well-being of our large manufacturing population. But it would be foreign to my present purpose to pursue the subject here, and I have already said enough to shew the necessity which exists of consulting variety in the exercise and employments of the young.

To render exercise as beneficial as possible, particularly in educating the young, it ought always to be taken *in the open air*, and to be of a nature *to occupy the mind* as well as the body. Gardening, hoeing, social play, and active sports of every kind, cricket, bowls, shuttlecock, the ball, archery, quoits, hide-and-seek, and similar occupations and recreations well known to the young, are infinitely preferable to regular and unmeaning walks, and tend in a much higher degree to develope and strengthen the bodily frame, and to secure a straight spine and an erect and firm but easy and graceful carriage. A formal walk is odious and useless to many girls who would be delighted and benefited by spending three or four hours a-day in spirited exercise and useful employment.

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* Leonard Horner on the Employment of Children in Factories and other Works, p. 51-2. Longman & Co. 1840.

Let those mothers, who are *afraid* to trust to Nature for strengthening and developing the limbs and spines of their daughters, attend to FACTS, and their fears will vanish. It is notorious that a majority of those girls who, in opposition to the laws of Nature, are encased in stays, and get insufficient exercise, become deformed—an occurrence which, on the other hand, is comparatively rare in boys, who are left, in conformity with the designs of Nature, to acquire strength and symmetry from free and unrestricted muscular action. In the girl the pressure of stays impedes the flow of blood to the muscles, which, being therefore imperfectly nourished, waste away. They lose their healthy red colour, and become pale and flabby; and, coextensively with this change, their contractile power diminishes. They are no longer able to hold the trunk erect, and spinal deformity necessarily ensues. Hence, in order to produce injurious consequences, a degree of pressure is sufficient, far below what is requisite to cause distortion of the chest, and compression of the respiratory and digestive organs. In a seminary for young ladies, containing forty pupils, it was discovered, on examination, by Dr Forbes, that *only two* out of those who had been resident in it for two years had straight spines; while out of an equal number of boys, imperfect as their exercise often is, it would be difficult to discover as many whose spines were not straight. Here, then, is ample proof, that stays, and absence of exercise, so far from contributing to an elegant carriage, are directly opposed to its acquisition; and that the absence of stays, and indulgence in exercise (even when not carried so far as the wants of the system require), instead of being hurtful to the spine, contribute powerfully to its strength and security. Yet such is the dominion of prejudice and habit, that, with these results meeting our observation in every quarter, we continue to make as great a distinction in the physical education of the two sexes in early life, as if they belonged to different orders of beings, and were constructed on such opposite principles, that what was to benefit the one must necessarily hurt the other. It is true that there are cases of *disease* in which the use of stays may be beneficially resorted to; but so far from sanctioning their general employment, such cases are sufficient to prove that, like every other remedy, they ought to be used only under the direction of the medical attendant.

Spinal deformity may arise either from habitual indulgence in a vicious posture, such as is occasionally contracted in writing or drawing, or from weakness of the muscles caused by deficient exercise, the use of stays, &c. In the former case, the spinal column, being bent to one side, retains for hours at a time in a state of tension the muscles of the opposite side, which thus seem to become elongated, and are unable to contract with sufficient power to hold the spinal column straight when an erect posture is attempted to be resumed. When the cause of the deformity lies in the general weakness of the muscles, the determination of the leaning to one side or the other is usually dependent on the habitual employment of the girl. In both cases the result is equally to be deplored; and I make this earnest appeal to mothers, because, in truth, *it is they who are responsible* to both God and man for any suffering entailed upon their children from this cause. They are the guides to whom their daughters look up with deference and respect, and if they neglect their trust, evil cannot fail to result. To mothers I would say,—Listen to the clear-sighted evidence of one of your own sex, whose worth and talents entitle her opinions and judgment to have weight with you, and who writes only to do good. "We are now so much accustomed to see delicate women," remarks Madame Necker de Saussure, "that, from want of good models, the ideal of a good figure has altogether disappeared from the imaginations of many. What features do we boast of in romance? Is it a dazzling freshness, or the graceful elasticity and vivacity of youth? No, it is a fragile and airy form, a sylph-like figure, an interesting paleness occasionally relieved by a tinge of carnation; it is an expressive look softly shaded by melancholy. But *the most of these indications are precisely those of feeble health.* Extreme delicacy of form, a colour which comes and goes, and a languor of expression, forbode nothing good for the future mother or wife, called upon perhaps to aid her husband in adversity. And yet, in the meantime, pictures of this kind fascinate the imagination of a young girl and even of a mother, and make them afraid of injuring charms so seductive. One young person will not eat from the fear of becoming too stout, another will not walk lest her foot should become too large. What miserable folly!"

"We have no wish to form Clorindas or stately Amazons; assuredly not; but the opposite extreme into which women have lately fallen, shews that the sex has degenerated. This complaint is heard everywhere, in England, in Switzerland, and even in America, more than any where else. The victims of maternity multiply daily, youthful widowers often afflict our sight. Physicians often forbid mothers from nursing, so much would it weaken both them and their nurslings. Numerous orthopedic (or deformity-correcting) establishments, sad and uncertain remedies for a defective education, are evidences of its fatal consequences. How does it happen that in an age remarkable for the progress of medical science, the application of hygiène to woman should be so much in arrear,—to that half of the human family on whom the health of the whole race essentially depends? To her will be due the existence of a healthy, active, and vigorous generation, or of one that is soft, vacillating, enervated, and subject to the empire of excessive nervous susceptibility, such as characterises so many women of the present day."

"In towns, especially, physical inaction and inability have deplorable effects. Much is believed to be done when the young girls are taken out to walk in fine weather. But what elasticity, I ask, can a monotonous march give them when they are compelled to keep themselves erect, to keep a guard on their expression, to take care of their clothes, and to speak very low? The blood is scarcely sufficiently accelerated by it to diffuse any heat through their limbs. The muscles of the arms, the shoulders, and the loins, remain inactive; those muscles which are so necessary in uniting the bones together, and preventing them from yielding, and which, by their free play, support and maintain the spinal column in its proper position; these very muscles receive no increase of strength from exercise; the spine, left to its natural flexibility, yields under the weight of the hand and arms, and becomes curved in its weakest part." *

Were there any real difficulty in determining the best means of developing the body and preventing deformity, even the comparison of savage with civilized man would at once remove it. Dr Henry Marshall, in his excellent work *On the Enlisting, the Discharging, and the Pensioning of Soldiers*, states, that "lateral curvature of the spine is intimately connected with civilized life. In the male sex, it occurs more frequently among boys who study very closely, clerks, and persons who exercise sedentary trades. The agricultural peasant is seldom affected with it, and *the tribes of people commonly denominated savage perhaps never*. I have had good opportunities of observing the form of the natives of

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* Madame Necker de Saussure sur l'Education Progressive, &c. Vol. iii., p. 168. Paris, 1838.

India, and of the Malay Islands, and I do not recollect having seen a single case of this deformity among them." P. 21. Dr Marshall's testimony is strongly supported by an intelligent old author, who, in describing the Caribs two centuries ago, says, in a tone of regret, "They do not swaddle their infants, but leave them to tumble about at liberty in their little hammocks, or on beds of leaves spread on the earth in a corner of their huts; and NEVERTHELESS *their limbs do not become crooked, and their whole body is perfectly well made.*" And again: "ALTHOUGH *the little creatures are left to roll about on the ground in a state of nudity, they* NEVERTHELESS *grow marvellously well,* and most of them become so robust as to be able to walk without support at six months old." *

The naïveté of this expression of surprise at the little Caribs growing *marvellously well* with the assistance of Nature alone, and without the use of stays and bandages imported from Europe, is extremely amusing, and shews to what extent prejudice and custom, once established, will continue to prevail, even where we have before our eyes the strongest evidence of their being hurtful. This worthy writer seems never to have allowed the thought to enter his head, that the Europeans *produced* the deformity by means of swaddling and bandages, and that the Caribs *escaped* it, simply by avoiding its causes, and giving liberty to both limbs and trunk of the body.

It is mentioned of the Araucanian Indians by a modern traveller, that "the children are never swaddled nor their bodies confined by any tight clothing." "They are allowed to crawl about nearly naked until they can walk." "To the loose clothing which the children wear from their infancy, may doubtless be attributed the total absence of deformity among the Indians."†

But there is another important consequence of excessive tasking of the mind, confinement within doors, and neglect of proper exercise in the open air, to which the attention of all mothers ought to be earnestly directed. I allude to the delicacy and lowered tone of the general health so graphically described by Madame Necker de Saussure, and which frequently assumes so many of the features of increased refinement as to be considered and hailed by the unreflecting mother as a new charm added to her daughter's former attractions. But too often this "interesting paleness," "sylph-like form," and "expression tinged with melancholy," are only the harbingers of a deep-seated and insidious disease, which is destined to destroy the mother's fondest hopes when excited to the utmost pitch. The same indications are often the first clear evidences of an infirmity of constitution which becomes, in its turn, the source of many evils, and which Mr Hare has shewn to precede, in most cases, the actual occurrence of spinal deformity in youth. In this sense, Mr Hare justly enough *considers the impaired health as the first stage of the spinal disease,* and affirms that the same amount of physical confinement would not be sufficient to produce the deformity if the general health remained unbroken.* In this view I entirely concur; and it affords a double reason for putting an end to the present system of excessive confinement and mental cultivation, which, there can be no doubt, frequently induces that form of impaired health which Sir James Clark has shewn to be so favourable to the production of tuberculous consumption, and which, when confirmed, is scarcely susceptible of cure.†

The evils of confinement are well illustrated by the contrast presented in the following example given by M. Fourcault. The general hospital of

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* Histoire Naturelle et Morale des Isles Antilles. Rotterdam, 1658.

† Stevenson's Narrative of a Twenty Years' Residence in South America, vol. i., pp. 9, 10.

* Hare on Spinal Diseases. London, 1838.

† Sir James Clark on Consumption and Scrofula.

Lille, he tells us, contains a considerable number of poor children abandoned to the charity of the public. The children, after having been reared in the country, are transferred to the town when considered old enough to work. The girls, however, are confined to the hospital, and spend the day engaged in needlework or other feminine employments which exercise only the fingers and hands; while the boys are for the most part bound to trades in the town. In consequence of this difference of treatment the boys in general become healthy and robust, and lose in a great measure their original tendency to scrofulous disease; while, under the influence of a sedentary life, the girls soon grow pale and chlorotic, and, with few exceptions, fall early victims to some form of scrofula.*

The next rule for the regulation of exercise is, that *it should always be proportioned in amount to the age, strength, state of the constitution, and former habits of the individual.* From overlooking this condition, it is usual for persons of an indolent or sedentary habit to tell the physician, when he urges upon them the necessity of exercise, that even a short walk fatigues them so much as to render them unfit for everything for some days afterwards, and that they are never so well as when allowed to remain in the house. But if, in perfect reliance on the regularity of the Creator's laws, we seek out the cause of this apparent exception, we shall almost uniformly find, that, instead of beginning with a degree of exertion proportioned to the weakened state of the system, such persons have (under the notion that it was not worth while to go out for a short time) forced their muscles, already weakened by inactivity and confinement, to perform a walk to which only regularly exercised muscles were adequate. The amount of exertion which is always followed by exhaustion is thus, through mere impatience and ignorance, substituted for that lesser degree which always gives strength; and because the former is followed by headach and debility, it is argued that the latter also must be prejudicial! Many sensible people delude themselves by such puerile plausibilities as this; and it is only by the diffusion of knowledge of the laws of exercise as part of a useful education, that individuals can be enabled to avoid such mistakes. This, however, will be made more clear by the following considerations:—

When any living part is called into activity, the processes of waste and renovation, which are incessantly going on in every part of the body, proceed with greater rapidity, and in due proportion to each other. At the same time the vessels and nerves become excited to a higher action, and the supply of arterial or nutritive blood and of nervous energy becomes greater. When the active exercise ceases, the excitement thus given to the vital functions subsides, and the vessels and nerves return at length to their original state.

If the exercise be resumed frequently and at moderate intervals, the increased action of the blood-vessels and nerves becomes more permanent, and does not sink to the same low degree as formerly; NUTRITION *rather exceeds waste, and the part consequently* GAINS *in size, vigour, and activity.* But if the exercise be resumed too often, or be carried too far, so as to fatigue and exhaust the vital powers of the part, the results become reversed; WASTE *then exceeds nutrition, and a* LOSS *of volume and of power* takes place, accompanied with a painful sense of exhaustion and fatigue. When, on the other hand, exercise is altogether refrained from, the vital functions decay from the want of their requisite stimulus; little blood is sent to the part, and nutrition and strength fail in equal proportion. A limb which has been long in disuse becomes weak and shrivelled from this cause, and its muscles present an unusual paleness and flabbiness, strongly contrasting with the florid redness and rigid fulness of the muscles of a well-exercised limb. It is solely because the left hand is less exercised than the right, that the muscles of the right arm and hand excel those of the left in bulk and strength. In left-handed persons the reverse is the case.

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* Causes Générales des Maladies Chroniques, p. 41.

Even sensation gives faithful notice of these changes, and therefore serves as a guide to the amount of exercise. When muscular employment is neglected, the body becomes weak, sluggish, and unfit for powerful efforts, and all the functions languish. When exercise is taken regularly and in due proportion, a grateful sense of activity and comfort prevails, and we feel ourselves fit for every duty, both mental and bodily. Lastly, when we are subjected to excessive exertion, a painful sense of weariness and exhaustion ensues, which is not relieved by rest, and which for a long time prevents sleep. A person who has greatly over-fatigued himself in walking, for example, is feeble and restless; and, on lying down, either cannot sleep at all, and rises in the morning weak in body and languid in mind; or has uneasy and disturbed sleep till the exhaustion is partially recovered from, after which he may enjoy sound and refreshing repose. The cause of the inability to sleep is exhaustion of the nervous energy. The movements of respiration are independent of the will, and spring from the nervous stimulus issued by the medulla oblongata or superior portion of the spinal cord. But in cases of excessive fatigue the medulla "partakes of the general exhaustion, and cannot maintain the respiration without assistance from voluntary efforts. Hence the feeling of oppression, and the frequent sighing which banish all repose; or if sleep do ensue it is disturbed by startings and fearful dreams, occasioned by the painful sensation of imperfect breathing."* In such cases sleep is frequently produced by the exhibition of stimulants, which impart an artificial strength, and thus afford the nervous system time to recruit.

The vital action of the muscles and of the nerves is dependent upon the normal constitution and arrangement of the molecules which compose their tissues, and any derangement of these is necessarily followed by derangement of healthy action. In the animal organism the nerves and muscles, as has already been explained, are so mutually dependent, and so intimately associated together, that the action of the one necessarily involves the action of the other. The muscle requires the nerve for the conveyance of its stimulus, and the nerve requires the muscle for the performance of the mandates which it transmits. But disturbance of the normal molecular condition in the muscle or in the nerve interferes with functional efficiency, and in extreme cases acts so powerfully that the nerve becomes totally incapable of transmitting a stimulus, and the muscle of acting in obedience to it. All vital action is accompanied by a molecular change; and continued action, or the sum of a number of minor actions, therefore produces an accumulating quantity of molecular changes. In the present state of science we are unable to make these changes in the nerve physically visible, but we possess in galvanism and electricity a means of demonstrating their reality. With the microscope we can detect no change in the filament which is conveying a mandate, but we perceive that a nerve, through which a number of discharges of galvanism or electricity has passed, ceases to be able to convey a stimulus to a muscle. A change has taken place in its molecular condition, and this change has enfeebled or destroyed its vital action. From the state of inefficiency so produced it recovers by repose, and again acquires the power of exciting the muscle to contraction. In like manner the *muscle* is dependent on its molecular condition for its power of action. Excessive exercise alters this condition, thereby weakening its contractile power, and producing exhaustion of the muscular force. The reality of this molecular change is apparent in the softened tissue of a muscle through which a prolonged stream of galvanism has been conducted, or which has undergone much fatigue in the living body. From this exhausted state the muscle, like the nerve, recovers by repose; for which a shorter or longer time is necessary, according to the amount of fatigue undergone, and the previous condition of the nervous and muscular tissues. The vital powers of a nerve or muscle are much more speedily exhausted in a weakly ill-nourished individual, than in one who is strong and well-fed. This well-known truth has been experimentally proved; the muscular irritability of ill-fed animals very soon disappearing, and their muscles refusing to obey the galvanic stimulus. But the molecular condition, and consequently the contractile power, of a muscle, is dependent on the flow of blood, as well as on the nervous stimulus; for the ligature of the blood-vessels destroys muscular action equally with the section of the nerve. In both cases the nutrition of the muscle suffers; it becomes pale and flabby, and wastes away. There is reason to believe, moreover, that the molecular condition of the nerves and muscles in the warm-blooded animals is intimately connected with the normal temperature of their bodies, as a variation of a few degrees above or below this point seriously affects nervous and muscular action; * and herein, it would appear, lies one important reason why Nature has so decidedly fixed the degree of the animal heat. In cold-blooded animals the same vital laws do not apply; for we find that they may undergo changes of temperature which would speedily prove fatal to the higher animals. Fishes may even be frozen so hard that they may be split with a hatchet, and yet can retain vitality.

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* See Williams' Principles of Medicine, 2d ed., p. 96.

The foregoing remarks have been made with the view of attaching some definite meaning to the expressions "muscular and nervous energy;" to shew that they represent a peculiar and material condition of the muscular and nervous tissues, and to explain that fatigue and exhaustion are not dependent simply on the amount of work that has been performed, but are also intimately connected with the condition of the working tissues. Fatigue which does not overstep the renovating powers of repose and nutrition may be permanently supported; whereas one day's excessive fatigue from passing this bound may so alter the molecular condition of the nervous and muscular tissues, that weeks of repose may be necessary to restore them to their normal condition. Indeed it is not an unusual occurrence for death to follow some great exertion in weakened states of the system. Valentin has remarked that muscular irritability is exhausted in a quicker ratio during the first periods of exercise than during the later, and we see this daily exemplified in the amount of labour which muscles are capable of undergoing long after the first ebullition of delight in muscular motion has passed away. The power of enduring fatigue varies remarkably in different individuals, and is either congenital or acquired. The congenital power depends on some peculiarity of molecular arrangement which we include in what is vaguely called "temperament," while the acquired power is connected with the greater ease with which nutrition keeps up or restores the working molecular condition according to physiological laws which have already been explained.

It remains to be observed, that excessive exercise, besides exhausting in this way the nervous and muscular energy, likewise alters the constitution of the blood itself. This is sufficiently proved by its fluid state in animals that have been hunted to death, and by the rapidity with which in such cases the body passes into putridity. In cases of extreme fatigue the powers of nutrition are necessarily impaired; and accordingly, with a much less degree of these morbid alterations, the vital metamorphoses cease to be normally performed, the animal temperature falls, and disease becomes imminent. The analogous changes produced in the blood of individuals who have

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* See Valentin's Lehrbuch, vol. ii., p. 68.

undergone much muscular fatigue, together with the concomitant nervous exhaustion, afford an ample explanation why soldiers and others worn out with prolonged marches rarely recover from attacks of fever.

In health the action of the muscles is performed with so little fatigue, that we are apt to overlook or undervalue the amount of labour they are in the habit of performing. The muscles of the lower extremities of a healthy man will carry his body, weighing perhaps from 150 to 200 lb., a distance of thirty miles, for several days in succession, without any great fatigue. The amount of work which is thus performed will be properly appreciated by any one who will carry on his shoulders a weight equal to that of himself even a single mile. The power of the muscles is in a great degree dependent upon training or on habit, and man, as a muscular machine, is capable of undergoing an amount of work that at first sight seems almost impossible. "Captain Head," says Mr Darwin, "has described the wonderful loads which the 'apires' (miners of Chili), truly beasts of burden, carry up from the deepest mines. I confess I thought the account exaggerated; so that I was glad to take an opportunity of weighing one of the loads, which I picked up by hazard. It required considerable exertion on my part, when standing directly over it, to lift it from the ground. The load was considered under weight when found to be 197 pounds. The apire had carried this up eighty perpendicular yards,—part of the way by a steep passage, but the greater part up notched poles, placed in a zigzag line up the shaft. According to the general regulation the apire is not allowed to halt for breath, except the mine is 600 feet deep. The average load is considered as rather more than 200 pounds; and I have been assured that one of 300 pounds (twenty-two stones and a-half), by way of trial, has been brought up from the deepest mine! At this time the apires were bringing up the usual load twelve times in a day; that is, 2400 pounds from eighty yards deep; and they were employed in the interval in breaking and picking ore.

"These men, excepting from accidents, are healthy, and appear cheerful. Their bodies are not very muscular. They rarely eat meat once a-week, and never oftener, and then only the hard dry charqui (meat dried in the sun). Although with a knowledge that the labour was voluntary, it was, nevertheless, quite revolting to see the state in which they reached the mouth of the mine; their bodies bent forward, leaning with their arms on the steps, their legs bowed, their muscles quivering, the perspiration streaming from their faces and their breasts, their nostrils distended, the corners of their mouth forcibly drawn back, and the expulsion of their breath most laborious. Each time they draw their breath, they utter an articulate cry of 'ay-ay,' which ends in a sound rising from deep in the chest, but shrill like the note of a fife. After staggering to the pile of ore, they emptied the 'curpacho'; in two or three seconds recovering their breath, they wiped the sweat from their brows, and, apparently quite refreshed, descended the mine again at a quick pace. This appears to me a wonderful instance of the amount of labour which habit, for it can be nothing else, will enable a man to endure."*

The amount of labour is indeed wonderful, but there can be little doubt that it is excessive, and prejudicial to the health of the miners. Mr Darwin, it is true, says they are healthy, and apparently cheerful; but he leaves us without any data to determine how long such work can be supported without the system giving way. That it does suffer, appears from what he says in another passage, when speaking of the mines of Yaquil: "When we arrived at the mine, I was struck by the pale appearance of many of the men, and inquired from Mr Nixon concerning their condition."† This pallor, in conjunction with the "little muscular deyelopment of their bodies," shews that the work was out of proportion to the strength; and we have little doubt that this view would be borne out by prolonged observation and correct statistical returns.* It is well known that under the Spanish rule the labour in the mines proved most fatal to the Indians. Excessive toil prevents the due nutrition of the body even when the food is of the most nutritious sort; but when hard labour and innutritious food are combined, the natural and inevitable result must be imperfect development of the body. Hence, in France, where the peasantry are poorly fed, agricultural labourers are frequently seen with arms and legs remarkable for tenuity.* That this poor muscular development is entirely due to the want of a just proportion between the food supplied and the work performed, appears from the fact that when the French peasant joins the army and receives a more nourishing diet, his muscular system becomes much more developed; while the state of attenuation returns when he leaves the ranks and resumes his former hard work and poor fare. During the construction of the French railroads it was observed that the well-fed English labourers performed twice the amount of work done by their French companions—till the latter, by increasing the nutritive quality of their diet, greatly added to their working powers.† Excessive labour, therefore, cannot fail to prove detrimental to the well-being of the organism, although life may bear up against it for a considerable time. That it is totally at variance with the dictates of physiology is shewn by the regularity with which in nature we find the instrument proportioned to the work it has to perform. Thus in birds, the pectoral muscles, which frequently keep the wings in unremitting motion for many hours in succession, are large and massy, while those which move the legs are comparatively small.

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* Darwin's Journal of the Voyage of the Beagle, p. 340.

† Op. cit., p. 265.

From this exposition of the effects of exercise in its different stages, it becomes easy to deduce rules applicable to all, for promoting the healthy development of the muscular system, and to trace the errors by which indolent people are accustomed to maintain that exercise is hurtful to their constitutions. *The second stage of exercise, or that in which, by its frequency, moderation, and regularity, nutrition and vigour are preserved at their highest pitch, is of course to be aimed at;* but the quantity of exercise which corresponds to it, must vary according to the constitution and previous habits of the individual, as is well exemplified in training for pedestrian feats, for the ring, and for racing. *The assertion made by many, that exercise hurts them, arises entirely from overlooking this circumstance.*

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* According to M. Laisné, a man of average weight (65 kilogrammes, or 143 lb. avoirdupois) will carry in a perpendicular direction a load equal to his own weight at the rate of 94·5 inches in the minute, during six hours as an average day's work (*Annales d'Hygiène*, April 1849, p. 318). He would thus raise 143 lb. 2332 feet in a day, or bring 1687 lb. from a depth of 80 yards—being about a third less work than that done by the Chilian miner. If we rightly understand the extracts from Mr Mayhew's letters in the *Morning Chronicle*, given by Dr Carpenter in the appendix to his *Essay on Alcoholic Liquors* (p. 278), it would appear that the coal-heavers on the Thames are capable of raising far greater weights than even those mentioned by Mr Darwin. The sack of coals, it is stated, weighs 238 lb., and is carried up from the ship's hold by a ladder 16 feet high. One man says,—"I have backed as many as sixty tons in a day since I took the pledge, and have done it without any iutoxicating drink with perfect ease to myself, and walked five miles to a temperance meeting afterwards." If this implies that the man carried 60 tons of coals up 16 feet of perpendicular height in the course of a day, it far surpasses the work done by the Chilian miner, which is equivalent to 16 tons raised 16 feet. M. Laisné's case would give 11⅓ tons raised 16 feet. There must, however, be some mistake. Sixty tons contain 564 sacks of 288 lb. each, and, supposing the man to work 12 hours a-day, he would have only about 1¼ minute to get the sack placed on his shoulders, to carry it up the ladder, to lay it down and return—an amount of dispatch which appears impossible.

* De l'Influence Comparative du Régime Animal, par E. Marchand, p. 198. Paris, 1849.

† Annales d'Hygiène Publique, January 1851, p. 80.

A person, accustomed to daily activity, will feel invigorated by a walk of four or five miles in the open air, whereas the same distance will weaken another who has not been in the habit of walking at all. But, instead of inferring from this, as is often done, that exercise in the open air is positively hurtful to the latter, reason and experience coincide in telling us, that he has erred only in over-tasking the powers of his system, and that to acquire strength and activity, he ought to have begun with one mile, and to have gradually extended his walk in proportion as the muscles became invigorated by the increased nutrition consequent on well regulated exercise. A person recovering from fever begins by walking across his room perhaps ten times in a day, and gradually extends to twenty or thirty times, till he gains strength to go into the open air. On going out, a walk of ten minutes proves sufficient for him at first; but by degrees his strength and flesh increase, and his exercise is prolonged till he arrives at his usual standard. Such is the order of Nature; but many sedentary people have no patience for such slow progress. When urged to take exercise, they grudge the trouble of going out for a short time, and think that, if a walk of half a mile does them good, one of a whole mile will do more; and when they suffer from the error, they shelter their ignorance under the general assumption that exercise does not agree with them! And the same persons who argue thus would think themselves entitled to laugh at the Irishman, who, finding himself relieved by five pills taken at night, inferred that he would necessarily be cured if he took the whole boxful at once, and on doing so narrowly escaped with his life.

From these principles it follows, *first*, that, to be beneficial, exercise should always be proportioned to the strength and constitution, and not carried beyond the point, easily discoverable by experience, at which waste begins to exceed nutrition, and exhaustion to take the place of strength; *secondly*, that it should be regularly resumed after a sufficient interval of rest, in order to ensure the permanence of the healthy impulse given to the vital powers of the muscular system; and, *lastly*, that it is of the utmost consequence to join with it a mental and nervous stimulus. Those who go out only once in four or five days, are always at work, but never advancing: for the increased action induced by the previous exercise, has fully subsided long before the succeeding effort is begun; and, so far as increased nutrition, strength, and aptitude for exertion are concerned, no progress whatever is made.

From the influence which muscular activity exercises upon the general circulation, and also in increasing the waste from the system, it is evident that *the supply of nourishment ought at all ages to hold a direct relation to the activity of the mode of life*, particularly in youth, when fresh materials are required for growth, as well as to repair the waste caused by exercise. In strict conformity with this principle, the first effect of exercise, if properly regulated, is always to increase the appetite; and hence in youth a quantity of food is both required and digested, which, at a more inactive period of life, would speedily oppress the system and disorder the health. If this full supply of nourishment be denied, the development of the bodily organs often receives a check which no subsequent treatment can remedy, and a foundation is laid for diseases of debility which afterwards embitter and endanger life. From pretty extensive inquiry, I am satisfied that in boarding-schools, especially for females, this important principle is occasionally disregarded; while the conductors are without the least suspicion of the evil they are producing, and even take credit to themselves for checking sensual appetites, and promoting temperance in eating as well as in drinking. They forget, or are ignorant, that the chemical changes which the tissues of the body undergo for the support of vitality, are much greater in youth than in maturity, and that, consequently, a greater allowance of food is necessary in the former case than in the latter for the support of an equal weight of body. If we take the amount of carbonic acid given off by the lungs as a standard by which to judge of the amount of food required, we find, from the calculations of Valentin, founded on the experiments of Andral and Gavarret, that for equal weights of body it ought to be one-third more between the ages of eight and fifteen than between thirty and forty.* H. Nasse, too, calculates that a boy of six consumes, weight for weight, about one-third more than a male adult, and one-half more than a woman.† Conductors of boarding-schools should also remember that it is during the period of rapid growth that health most readily suffers from disregard of the physiological laws, and that if the diet be then insufficient, the blood speedily becomes impoverished. The ill-nourished muscles consequently become weak and attenuated, and their irritability or power of responding to a stimulus is diminished. Hence their contractile power is readily exhausted, and they yield much sooner to the effects of a continued strain. Herein lies one of the chief causes of spinal deformity. Youth, therefore, requires the best and most nutritious food, and such ought regularly to be provided. The infringement of this condition entails much misery upon our young manufacturing population. Wasted by excessive labour, long confinement, and miserable diet, the muscular system is stinted in growth and weakened in structure; and the blood, impoverished by insufficiency of nourishing food and by a vitiated atmosphere, is no longer capable of repairing the waste consequent upon exercise, or of affording a healthy stimulus to the vessels and nerves which animate the muscles. Languor, debility, and exhaustion of mind, necessarily follow; and the individual is left susceptible of no stimulus but that of ardent spirits or of excited and reckless passion. In health, consequently, activity and appetite are generally proportioned to each other, and those suffer most who attempt to combine the pleasures of appetite with bodily indolence.

The next subject for consideration is *the times at which exercise should be taken*. Those who are in perfect health may engage in exercise at almost any hour, except immediately after a full meal; but those who are not robust, ought to confine themselves within narrower limits. To a person in full vigour, a good walk in the country before breakfast may be highly beneficial and exhilarating; while to most invalids and delicate persons, it will prove more detrimental than useful, and will induce a sense of weariness which will spoil the pleasure of the whole day. To some, however, who have no appetite on rising, a short walk in the open air before breakfast proves very beneficial. All that is required is, that we should not prescribe morning exercise indiscriminately, but only in the class of cases for which it is adapted. From losing sight of this precaution, many persons, deceived by the current poetical praises of the freshness of morning, hurt themselves in summer by seeking health in untimely promenades.

In order to prove beneficial, exercise must be resorted to only when the system is sufficiently vigorous to be able to meet it. In delicate constitutions, this is the case at the end of from two to four hours after a moderate meal, and consequently the forenoon is the best time for them. If exercise be delayed till some degree of exhaustion from the want of food has occurred, it speedily dissipates instead of increasing the strength which remains, and impairs rather than promotes digestion. The result is quite natural; for exercise of every kind causes increased action and waste in the organ, and if there be not materials and vigour enough in the general system to keep up that action and supply the waste, nothing but increased debility can reasonably be expected.

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* Lehrbuch, vol. i., p. 583.

† Wagner's Handwörterbuch der Physiologie, vol. iv., p. 102.

For the same reason, exercise *immediately before meals,* unless of a very gentle description, is injurious, and an interval of rest ought always to intervene. Muscular action causes an afflux of blood and nervous energy to the surface and extremities, and if food be swallowed whenever the activity ceases, and before time has been allowed for a different distribution of the vital powers to take place, the stomach is taken at disadvantage, and from want of the necessary action in its vessels and nerves, is unable to carry on digestion with success. This is very obviously the case where the exercise has been severe or protracted, and the consequence is so well known, that it is an invariable rule in the management of horses, never to feed them immediately after work, but always to allow them an interval of rest proportioned to the previous labour. "Eat not," therefore, "until you be fully reduced to that temper and moderate heat as when you began, and when the spirits are retired to their proper stations."* Even instinct would lead to this conduct, for appetite revives after repose.

Active exercise ought to be equally avoided *immediately after* a heavy meal. In such circumstances, the functions of the digestive organs are in the highest state of activity; and if the muscular system be then called into considerable action, the withdrawal of the vital stimuli of the blood and nervous influence from the stomach to the extremities, is sufficient almost to stop the digestive process. This is no supposition, but demonstrated fact; and, accordingly, there is a natural and marked aversion to active pursuits after a full meal. In a dog which had hunted for an hour or two directly after eating, digestion was found on dissection to have scarcely begun; while in another dog, fed at the same time, and left at home, digestion was nearly completed.

A mere stroll which requires no exertion, and does not fatigue, will not be injurious before or after eating, but, on the contrary, may under certain circumstances be beneficial, as tending to break an engrossing train of thought which would have proved detrimental to digestion. Beyond this limit, however, exercise is at such times hurtful. All, therefore, whose object is to improve or preserve health, and whose occupations are in their own power, should arrange these so as to observe faithfully this important law, for they will otherwise deprive themselves of most of the benefits resulting from exercise.

When we know that we shall be forced to exertion soon after eating, we ought to make a very moderate meal, in order to avoid setting the stomach and muscles at variance with each other, and exciting feverish disturbance. In travelling by a stage-coach or railway, where little repose is allowed, this precaution is invaluable. If we eat heartily as appetite suggests, and then enter the coach, restlessness, flushing, and fatigue, are inevitable; whereas, by eating sparingly, the journey may be continued for two or three days and nights, with less weariness than is felt during one-fourth of the time under full feeding. I observed this when travelling as an invalid on rather low diet, and was surprised to find myself less fatigued at the end of seventy-two hours, than I had previously been when in health and living fully, after half such a journey; and I have heard the same remark made by others, also from experience. In such cases, however, the confined air of the carriage, by checking the insensible action of the skin and impeding the aëration of the blood,* must influence digestion, and is thus not without effect in producing the unpleasant results; accordingly, we find that travellers in an open carriage do not suffer the same amount of inconvenience from a hasty meal. But for full information on this and other practical questions connected with diet and digestion, I must refer the reader to my separate work, in which they are discussed in detail.*

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* Maynwaringe, p. 14.

* See chapter xi. of the present work.

It is the custom in many families and schools, apparently for the purpose of saving time, to take young people out to walk about the close of the day, because there is not light enough to do any thing in the house. Nothing can be more injudicious than this plan—for, in the *first* place, *exercise once a-day is very insufficient for the young*, and even supposing that it were enough, the air is then more loaded with moisture, colder, and proportionally more unhealthy, than at any other time; and, *secondly*, the absence of the beneficial stimulus of the solar light, diminishes not a little its invigorating influence. Consequently, for those who are so little out of doors as the inmates of boarding-schools and children living in towns, and who are all at the period of growth, *the very best times of the day should be chosen for exercise*, particularly as in-door occupations are, after nightfall, more in accordance with the order of nature. In large cities it is desirable that the walk should be taken towards the quarter whence the wind is blowing, so as to escape as much as possible the smoke of the town, which corrupts the air, and proves irritating to delicate lungs. It is principally on account of the smoke that many individuals with delicate chests, who enjoy good health in the country, cannot remain in a large town without suffering from bronchitic attacks; and as it is generally towards the close of the day that the cloud of smoke hangs most densely over the city, walking at this time should be studiously avoided by all who are liable to pulmonary attacks. Invalids should choose their residence at that end of the town which is first reached by the prevailing winds, so as to enjoy the greatest amount of pure air. The prevalence of west winds in Britain is doubtless the chief reason why the west-end has become the fashionable quarter of cities.

By devoting part of the forenoon to exercise, another obvious advantage is gained. If the weather prove unfavourable at an early hour, it may clear up in time to admit of going out later in the day; whereas, if the afternoon alone be allotted to exercise, and the weather then prove bad, the day is altogether lost. In winter, indeed, it is not unusual for girls to be thus confined from Sunday to Sunday, simply because the weather is rainy at the regular hour of going out. When the muscular system is duly exercised in the open air early in the day, the power of mental application is considerably increased; while, by delaying till late, the efficiency of the whole previous mental labour is diminished by the restless craving for motion which is evinced by young people, and which, when unsatisfied, distracts attention, and leads to idleness in school. It would be well to copy in this respect the practice adopted in the infant schools, where the children are turned out to play for a few minutes, as soon as the wandering of mind and restlessness of body indicate that the one has been too much and the other too little exerted. After such an interval, work again goes briskly on, and every one is alive. For these reasons I cannot too strongly condemn the system still pursued even in our best schools, of confining the young during the whole day at lessons, or preparations for lessons, with the exception of only one hour, or an hour and a half, of intermission. I am acquainted with an excellent and very large school of this kind where the boys are allowed only an hour and a half for play, and in this the dinner time is included! By way of making the most of every moment, the boys are led out to play at foot-ball the instant dinner is swallowed. This is well meant, as is proved by the masters sharing in the play; but a more irrational method could not be devised.

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* The Physiology of Digestion, &c., 9th edit., chapters viii. to xiii.

Three hours at least ought to be spent in the open air daily, and five hours would be still better—joined, of course, to useful occupation.

The *different kinds of exercise* fall now to be considered. The object being to employ all the muscles of the body, exercise should be often varied, and always adapted to the peculiarities of individuals. Speaking generally, *walking* agrees well with every body; but as it brings into play chiefly the lower limbs and the muscles of the loins, and affords little scope for the play of the arms and muscles of the chest, it is insufficient of itself to constitute adequate exercise. Hence the advantage of combining with it movements performed by the upper half of the body, as in rowing a boat, fencing, shuttlecock, and many other useful sports. Such exercises have the additional advantage of animating the mind, and, by increasing the nervous stimulus, making exertion easy, pleasant, and invigorating. Nature, indeed, has shewn her intention that the upper part of the body should always partake in the exercise of the lower, by rendering it impossible for us even to walk gracefully without the arms keeping time, as it were, with the movements of the legs.

Active play, running, leap-frog, foot-ball, cricket, gardening, and pedestrian, botanical, and geological excursions, combine in their results all the advantages which well-conducted exercise is capable of yielding; and the last are much resorted to in the German seminaries, for the purpose of developing the mental and bodily powers. On the Continent generally, more attention is paid to physical health and development in the education of the young than with us; and in many institutions a regular system of useful manual occupation is substituted for mere play, and with decided advantage. For not only is the physical organism thereby strengthened and developed, but the mental energy and dignity of character are increased, and the mind becomes better fitted for independent action. Among the ancients the training and invigoration of the body formed a leading object in education; but physical strength having become of less importance in war since the invention of gunpowder, the moderns have too generally restricted their attention to the direct improvement of the mind.

In summer, walking excursions to Wales and the Highlands of Scotland are common among the youth of our cities, and when proportioned in extent to the constitution and previous habits of the individual, nothing can be more advantageous and delightful. But not a season passes in which health is not sacrificed and life lost by young men imprudently exceeding their natural powers, and undertaking journeys for which they are totally unfit. It is no unusual thing for youths, still weak from rapid growth, and perhaps accustomed to the desk, to set out in high spirits at the rate of twenty-five or thirty miles a-day, on a walking excursion, and (from carrying exercise, for days in succession, to the third degree, or that in which *waste exceeds nutrition*) to come home so much worn out and debilitated that they never recover. A like fate often befalls students of the natural sciences, as a result of the annual geological or botanical tour. The professor or teacher, himself probably of robust frame, and able from constitutional aptitude or training to undergo much fatigue, too often regulates the day's work more in accordance with his own wishes and capabilities than with the strength of his companions, forgetful that the amount of exercise which he can undergo with benefit may prove permanently injurious to their immature constitutions. Chossat's experiments have demonstrated that the chemical changes of destructive assimilation (as Dr Prout has termed the conversion of the animal tissues into the various excretions) go on much more rapidly in young than in adult animals. Hence the former, if exposed to starvation, and, we may analogically suppose, to hard work, are much sooner reduced than the latter. Thus, young turtle-doves were found by Chossat to die after 3·07 days' starvation, losing daily ·081, or nearly 1-12th, of their original weight; while the mature birds supported life during 13·36 days' starvation, losing daily only ·035, or about 1-28th, of their original weight. All vital action is dependent on a due supply of blood, and the amount of work which the muscles are capable of performing is therefore dependent on the quantity and quality of the blood supplied to them. A strong man is speedily reduced to weakness by a copious bleeding; and chemical examination shews that the blood in youth and in females is more watery than that of a male adult, and approaches in constitution to that of a man who has been largely bled. Experience, accordingly, proves that adults may lose comparatively much more blood than growing youths without suffering permanent injury, because not only are the solid materials of their blood more abundant, but its fibrin, on which the nutrition of the muscles eminently depends, is in them firmer and denser, and offers greater resistance to the decomposing effects of chemical agents, such as oxygen.

These facts serve to explain why young soldiers, whose growth is scarcely finished, die in great numbers when exposed to long and heavy marches, particularly when food is at the same time scanty. Violent exercise is not less pernicious, and, as Dr Johnson well remarks, "it did great harm even when nations were more in a state of nature than they now are. Galen, in his discourse on Thrasybulus, inveighs against the athletic practices of the gymnasium. A smart walk of a mile is to a valetudinarian what a furious wrestle would be to an athletic. If we trace those dreadful aneurismal affections of the heart and arteries in early life, we shall find their origins in violent exercise or sudden over-exertion, in nine cases out of ten, where age and ossification are not concerned." * Even a single day of excessive fatigue will sometimes suffice to interrupt growth and produce permanent bad health; and I know one instance of a strong young man, who brought on a severe illness and permanent debility, by sudden return to hard exercise for a single day, although, some years before, he had been accustomed to every species of muscular exertion in running, leaping, and swimming. Many young men hurry on the premature development of consumption by excessive fatigue during the shooting season, in cases where, by prudent management, they might have escaped it for years, if not altogether. The principle already laid down, of not exceeding *the point at which exercise promotes nutrition and increases strength*, will serve as a safe guide on all occasions, and indicate the rate at which it may be extended. Old sportsmen know the rule by experience, and generally prepare themselves for the moors by several weeks of previous training. The science and judgment which fox-hunters display in preparing their horses for exertions in coursing are well known, and might be still more usefully applied by their riders to the training of their own families. The whole method is based upon tolerably sound physiological principles. "The very best food," says a writer evidently familiar with the subject—"that which contains the greatest quantity of nutriment in the smallest space—is supplied to the racer with an unsparing hand; 'Get as much into him as possible' is the trainer's maxim, and inasmuch as the horse is thus abundantly supplied with the choicest aliment, *his exercise must be commensurate in a corresponding degree, or disease will ensue in a very short time.* It will be easily perceived that abundance of the choicest food is calculated to increase the muscle and to produce fat also; the former being conducive to strength, the latter to sluggishness. The animal is divested of the latter by exercise, by that exudation called perspiration; he is 'sweated' periodically, is thickly clad, and forced to continue a gallop perhaps of three miles; he is then stripped, the perspiration scraped off, he is rubbed dry and taken home; or in other words, the animal's food produces fat, his exercise sweats it away; his muscle is thus rendered hard, large, and elastic, and indeed his powers every way increased, since the tendon and even the bone derive the most essential benefit from the system under consideration. Further, as the horse is fed to repletion, as nature may be said to be overcharged, the trainer finds it requisite to have recourse to physic and bleeding in addition to extraordinary exercise to prevent disease.* Thus the racer is brought to the starting point in a state of perfection as regards his powers of speed and endurance—his tendon as large as possible, his muscle hard and developed to the utmost, but divested of fat; if any fat still remain, the horse cannot be in perfect condition."†

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* Johnson on Derangement of the Liver, &c., p. 129.

I once had occasion to examine carefully two young gentlemen, who, during their attendance at Cambridge, were in the habit of using very violent and continued exertion in rowing. In one the muscles of the arm and upper part of the chest were of an almost unnatural size and hardness from excess of nutrition, while the rest of the body was only moderately developed. In the other there was no such disproportion, but there was a liability to palpitations and severe pain in the region of the heart, which, he said, were first brought on by excessive exertion. On cautioning him against the probable consequences of continuing such trials of strength as occurred during their frequent boat-races, he told me, that in looking back to his own companions at college, he could name several dead within the last four years whose lives were distinctly ascertained to have been sacrificed in this way,—a fact strikingly corroborating Dr Johnson's testimony, and which certainly ought to make a salutary impression on the minds of those who, in the pursuit of pleasure, rush so thoughtlessly into danger.

As the subject is one of much practical importance, I add a melancholy but instructive example, with which a friend has furnished me, of the operation of the principles above inculcated. He says—"A young gentleman, whom I knew, was employed as a clerk in one of the banks in Edinburgh. He was closely confined to his desk during the summer, and towards the end of July had become weak and emaciated from deficient exercise in the open air. His strength continued to decline till Friday the 12th of August, when he went to shoot on Falkirk Moor. On Friday and Saturday he was much fatigued by the excessive and unusual exertion, and on Sunday evening was feverish and heated, and perspired very much during the night. In this condition, he rose about three or four o'clock on Monday morning, and returned to Edinburgh on the top of a coach. When he reached home he felt very unwell, but went to the bank. At two o'clock he became so sick as to be unable to sit at his desk. He was then bled by a medical gentleman, but without much effect; and after passing three months in a feverish and sleepless condition, he died in the beginning of November. He was previously of a healthy constitution." It is more than probable that this young man "perished for lack of knowledge" of the structure and functions of the human body.

Riding is a most salubrious exercise, and, where the lungs are weak, possesses a great advantage over walking, as it does not hurry the breathing. It calls into more equal play all the muscles of the body, and at the same time engages the mind in the management of the animal, and exhilarates by the free contact of the air and more rapid change of scene. Even at a walking pace, a gentle but universal and constant action of the muscles is required to preserve the seat, and adapt the rider's position to the movements of the horse; and this kind of muscular action is extremely favourable to the proper and equal circulation of the blood through the extreme vessels, and to the prevention of its undue accumulation in the central organs. The gentleness of the action admits of its being kept up without accelerating respiration, and enables a delicate person to reap the combined advantages of the open air and proper exercise, for a much longer period than would otherwise be possible.

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* This practice of "overcharging nature" cannot be accounted sound physiology: the trainer's object would be better attained by giving less food, and thus rendering the physic and bleeding unnecessary. The removal of the fat, moreover, is partially due to the increased exhalation from the lungs. The fatty matter (which is contained in larger quantity in venous than in arterial blood) combines with the oxygen of the inhaled air, and is exhaled as water and carbonic acid.

† Royal Leamington Spa Chronicle, Feb. 28, 1839.

From the tendency of riding to equalize the circulation, stimulate the skin, and promote the action of the bowels, it is also excellently adapted as an exercise for dyspeptic and nervous invalids.

Dancing is a cheerful and useful exercise, but has the disadvantage of being used within doors, in confined air, and often in dusty rooms and at most unseasonable hours. Practised in the open air, and in the day-time, as is common in France, dancing is certainly an invigorating pastime; but in heated rooms, and at late hours, it is the reverse, as these drawbacks do more harm than can be compensated by the healthful exercise of the dance.

Gymnastic and calisthenic exercises have been in vogue for some years, for the purpose of promoting muscular and general growth and strength, but they are now rather sinking in public estimation; partly, I believe, from irrationally making them supersede, instead of aiding, exercise in the open air, and partly from overlooking the necessity of adapting the kind and extent of them not only to the individual constitution, but to the natural structure of the body—the consequence of which has been, that some of the more weakly pupils have been injured by exertions beyond their strength, and discredit has thus been brought upon the system. It is certain, indeed, that some of the common gymnastic exercises are altogether unnatural and at variance with the design of the bodily organization; and that others are fit only for robust and healthy boys, and not at all for improving those who are delicately constituted, and who stand most in need of a well-planned training. It is impossible to enter minutely into this subject here; but the best course we can take is to follow the footsteps of Nature, and, before adopting any exercise, to consider whether it is in harmony with the mode of action assigned by the Creator to the parts which are to perform it. If it be so, we may proceed with perfect confidence that it will not only improve the health, but add to the freedom, elegance, precision, and strength of our movements; whereas, if it be opposed to the obvious intention of the Creator, we may rest assured that no good can accrue from it.

If, for example, we examine the various attitudes and motions of the body which occur in fencing, dancing, swimming, shuttlecock-playing, and some of the better class of gymnastic exercises, we find that they are not less graceful and beneficial to the young who engage in them, than pleasing to those by whom they are witnessed—just because they are in perfect harmony with nature, or, in other words, with the structure and mode of action of the joints, ligaments, and muscles by which they are executed. But it is far otherwise with some of the anomalous exercises which were at one time so fashionable, and which are not yet extinct in schools and gymnasia, and seem to have for their chief object the conversion of future men and women into foresters, firemen, or savages, rather than into beings who are to continue to have the use of stairs, ladders, carriages, steam-boats, and the other conveniencies of civilized life. It is, no doubt, a good thing for a boy to be able to climb up a perpendicular pole or a slippery rope, when no other means present themselves of attaining an important object at its upper end; it is an equally good thing for a young lady to be able to sustain her own weight hanging by one or both hands, when there is no possibility of resting her feet on *terra firma;* and where boys and girls are strong enough to take pleasure in such amusements, there is no great reason to hinder them, provided they are impelled to them not by emulation or any secondary motive which may lead to over-exertion, but by the pure love of the exercise itself. In all ordinary circumstances, those only who are vigorously constituted will attempt them, and, if left to themselves, they will be sure to desist before any harm can be done. But the case is entirely altered when such extraordinary evolutions are not only encouraged, but taught to all indiscriminately, whether they be strong or weak, resolute or timid. We have only to reflect for a moment on the structure of the shoulder-joint, and on the sphere of action of the muscles surrounding it, to perceive at once that the position of the one, and the strain upon the other, caused by the exercises alluded to, are so *forced* and *unnatural,* as to exclude the notion that the Creator can have intended either to be practised except upon occasions of urgent necessity; and to show how preposterous it is, therefore, to make such exercises a subject of general instruction. Nay, the very violence of the effort required to sustain the body when hanging by the hands, is far beyond that moderate exertion which adds to nutrition and to strength: in delicate subjects it may even induce relaxation and stretching of the ligaments and bloodvessels, and thus, as in the case of the young men at Cambridge, lay the foundation of future and fatal disease. The same remarks apply to a common practice of making the pupils slide down an inclined plane resting on the hands alone; by which unnatural effort the shoulders are pushed half-way up the neck, and the wrist, arms, and chest are severely tried. But in these and other similar evolutions, we need only look at the dragging and distortion which they produce, and which form such a painful contrast to the ease and grace of all natural motions and attitudes, to perceive that they are *out of the order of nature,* and that neither health nor elegance can result from them.

I am aware that these exercises are said to stretch the spine and to remedy its deformities; but it would be quite as sound logic to maintain that, because a *broken* leg requires to be tied up with splints and bandages, the best way to strengthen a *sound* leg must be to bandage it also, as to infer that, because a few *diseased* spines require to be stretched, all *healthy* spines must also derive benefit from the same process,—although, in the latter case, it is obvious to reason that the stretching will be much likelier to put the bones out of their places than to fix them more firmly in those which they already occupy. It is not by such extravagant means that a soldier-like carriage is obtained in the army; and yet there the uniformity of result—the erect and steady gait—is scarcely less remarkable than the discordant materials, and variety of slouching and awkward attitudes, out of which it is formed by perseverance in a rational system of drilling.

In the selection of exercises for the young, then, we should not be misled by a vain desire of surmounting difficulties and performing feats, at the serious risk of inducing aneurism or rupture; but rather endeavour to strengthen the body by active amusements, which shall call the social and moral feelings and intellect into play at the same time, and by the practice of such gymnastic evolutions only as tend to improve and give tone to the *natural action* of the muscles. And in endeavouring to attain this object, we should always be careful to avoid great fatigue, and to modify the kind, degree, and duration of the exercise, so as to produce the desired results of *increased nutrition and strength;* remembering that the point at which these results are to be obtained in perfection is not the same in any two individuals, and can be discovered only by experience and careful observation.

For giving strength to the chest, *fencing* is a good exercise for boys, and what is called *the club exercise* for females; but the above limit ought never to be exceeded, as it often is, by measuring the length of a lesson by the hour-hand of a clock, instead of its effects on the constitution. *Shuttlecock*, as an exercise which calls into play the muscles of the chest, trunk, and arms, is also very beneficial, and would be still more so were it transferred to the open air. After a little practice, it can be played with the left as easily as with the right hand, and it is therefore very useful in preventing curvature and giving vigour to the spine in females. It is an excellent plan to play with a battledoor in each hand, and to strike with them alternately. The play called *the graces* is also well adapted for expanding the chest, and giving strength to the muscles of the back, and has the advantage of being practicable in the open air.

Dumb-bells are less in repute than they were a few years ago; but when they are not too heavy, and the various movements gone through are not too eccentric or difficult, they are very useful. They do harm occasionally from their weight being disproportioned to the weak frames which use them; in which case they pull down the shoulders by dint of mere dragging. When this or any other exercise is resorted to in the house, the windows should be thrown open, so as to make the nearest possible approach to the external air.

Reading aloud, recitation, and singing, are more useful and invigorating muscular exercises than is generally imagined, and are extremely useful in promoting the development of the lungs and chest, at least when managed with due regard to the natural powers of the individual, so as to avoid effort and fatigue. They all require the varied activity of most of the muscles of the trunk, to a degree of which few are conscious till their attention is turned to it. In forming and modulating the voice, not only the chest but also the diaphragm and abdominal muscles are in constant action, and communicate to the stomach and bowels a healthy and agreeable stimulus: consequently, where the voice is raised and elocution rapid, as in many kinds of public speaking, the muscular effort becomes even more fatiguing than the mental, especially to those who are unaccustomed to it; and hence the copious perspiration and bodily exhaustion of popular orators and preachers. When care is taken, however, not to carry reading aloud or reciting so far at one time as to excite the least sensation of soreness or fatigue in the chest, and when the exercise is duly repeated, it is extremely useful in developing and giving tone to the organs of respiration, and to the general system. To the invigorating effects of this kind of exercise, the celebrated and lamented Cuvier was in the habit of ascribing his own escape from consumption, to which, at the time of his appointment to a professorship, it was believed he would otherwise have fallen a victim. The exercise of lecturing gradually strengthened his lungs, and improved his health so much that he was never afterwards threatened with any serious pulmonary disease. But of course this happy result followed only because the exertion of lecturing was not too great for the then existing condition of his lungs. Had the delicacy of which he complained been farther advanced, the fatigue of lecturing would only have accelerated his fate; and this must never be lost sight of in practically applying the rules of exercise.

It appears, then, from the foregoing remarks, that the most perfect of all exercises are those sports which combine free play of all the muscles of the body, mental excitement, and the unrestrained use of the voice; and to such sports, accordingly, are the young so instinctively addicted, that nothing but the strictest vigilance and fear of punishment can deter them from engaging in them the moment the restraint of school is at an end. Many parents, absorbed in their own pursuits, forgetful of their own former experience, and ignorant that such are the benevolent dictates of Nature, abhor these wholesome outpourings of the juvenile voice, and lay restrictions upon their children, which, by preventing the full development of the lungs and muscles, inflict permanent injury upon them in the very point where in this climate parents are most anxious to protect them. Accordingly, we find that what are called wild romping boys and girls, or those who break through all such restrictions, often turn out the strongest and healthiest; while those "good children" who submit are generally found to become more delicate as they grow older.

Enough, I trust, has been said to enable any rational parent or teacher to determine the fitness of the different kinds of muscular exercise, and to adapt the time, manner, and degree of each to every individual under his care. But, before taking leave of the subject, and with a view to impress still more deeply upon the mind of the reader the practical importance of the principles inculcated in the present chapter, I shall subjoin a case which affords an extremely apposite illustration of almost every one of them. The particulars were furnished to me by a young friend who was allowed to peruse the manuscript of these pages, and who, being himself the subject of the case, was struck with the perfect accordance between his own experience and the doctrines here propounded. It is proper to keep in view, that at the time of his experiment my friend was about seventeen years of age, and growing rapidly. I shall use nearly his own words.

After having passed the winter closely engaged in a sedentary profession, and unaccustomed to much exercise, he was induced by the beauty of returning spring to dedicate a day to seeking enjoyment in a country excursion; and for that purpose set off one morning in the month of May, without previous preparation, or even taking a more substantial breakfast than usual, to walk to Haddington by way of North Berwick,—a distance of 34 miles from his home. Being at the time entirely unacquainted with physiology, he was not aware that the power of exerting the muscles depended in any degree upon the previous mode of life, but thought that if a man had on any particular occasion been able to walk thirty miles without exhaustion, he must necessarily continue to possess the same power under all circumstances, while youth and health remained. The nervous stimulus arising from his escape from the desk, and from the expected delights of the excursion, carried him briskly and pleasantly over the ground for the first twelve miles, but then naturally began to decrease. Unfortunately, the next part of the road lay through a dull, monotonous, and sandy tract, presenting no object of interest to the mind, and no variety of any description; so that the mental stimulus, already greatly impaired in intensity, became weaker and weaker. Being *alone*, his feelings and intellect were unexcited by the pleasure of companionship and conversation; weariness consequently increased at every step; and long before his arrival at North Berwick (25 miles), "every vestige of enjoyment had disappeared, time seemed to move at a marvellously tardy pace, and every mile appeared doubled in length."

Not being aware that excessive exercise without a succeeding period of repose is unfavourable to digestion, and having a lively recollection of the pleasure and refreshment consequent upon eating a good dinner with an appetite whetted by a *proper* degree of bodily labour in the open air, he looked forward with confidence to some recompense and consolation for his toils when dinner should make its appearance. In this, however, he was doubly disappointed; for, from having started with too light a breakfast, and walked so far, his digestive organs were, in common with every part of his system, so much impaired that he looked upon the viands placed before him almost without appetite; and as they happened to be not of a very nutritive or digestible quality, he infringed still further that law of muscular action which requires a full supply of nourishing arterial blood, made from plenty of nutritive food—a law which I have stated to be most important, especially in youth and during growth.

After a rest of two hours, and taking a moderate allowance of wine, which, however, he says, "seemed to have lost its ancient virtue of imparting cheerfulness to the human heart," he set out to complete the remaining nine miles to Haddington. The country was more beautiful and varied, but the charms of nature had by this time lost all attractions; for our pedestrian was "now wholly occupied in counting the tedious miles yet to be traversed, and in vowing that this *pleasure excursion*, though not the first, should certainly be the last in his life." Being reduced to the utmost degree of exhaustion, it required an obstinate effort to drag himself along; but at last he arrived at Haddington, in a state of exquisite misery. Unable to read from fatigue, and having nobody to converse with, he sought refuge in bed at an early hour, in the expectation that "tired Nature's sweet restorer, balmy sleep," would visit his couch and bring him relief. But in accordance with what is mentioned on page 113, he tossed and tumbled incessantly till four o'clock in the morning, a period of seven hours, after which sleep came on. Next day my youthful friend returned home in the stage-coach, wiser at least, if not happier, for his pleasure excursion; and he now makes the observation, that if he had been even slightly instructed in the nature of the human constitution, he never would have entertained for a moment the expectation of enjoyment from a proceeding so utterly in defiance of all the laws of exercise, as that of which he reaped the unpalatable fruits. He adds truly, that the number of young men who suffer in a similar way is by no means small, and that he has reason to be thankful that he has not, like some of his companions, carried his transgression so far as permanently to injure health, or even sacrifice life.

My aim being practical utility, I have said nothing in this place on the subject of the muscles of organic life; that is to say, the *involuntary muscles*, strictly so called, or those over which the will has no power. These are the agents of important vital functions, which are carried on by them unconsciously to ourselves, and which it would have been dangerous to leave under our control. They seem to act chiefly in obedience to physical stimuli, each organ receiving that which is appropriate to it. The chief of the involuntary muscles is the heart, which goes on in one unvarying round of alternate contraction and relaxation, from the commencement till the close of existence, and which is dependent on the blood for its appropriate stimulus. The muscular fibres of the stomach and bowels are also most important muscles of the same class, and their contraction is due to the stimulus imparted by the contents of the alimentary canal. The beneficence of Providence in withdrawing entirely the muscles of organic life from our control cannot be sufficiently admired; for had the action of the heart depended on the exercise of the will, it would have ceased whenever sleep or any other cause deprived us of the power of attention, and life would in consequence have been extinguished. The process of digestion, too, so far as muscular action is concerned, would have become an intolerable burden, which, like the labour of Sisyphus, would no sooner have been finished than it must have been begun afresh. Of the nature of the movements of respiration, we shall speak when treating of that function in a subsequent chapter.

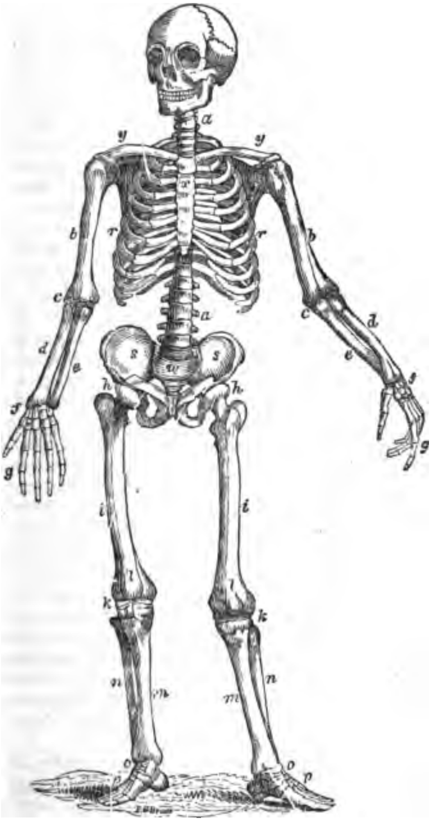
CHAPTER VIII.

THE BONES, THEIR STRUCTURE, USES, AND CONDITIONS OF HEALTH.

THE hardness, strength, and insensibility, which form the distinguishing properties of healthy bones, fit them in a remarkable degree for serving as a basis of support to the softer and more active textures of the body. By their means, the human frame is made to unite the most finished symmetry of form, with the most perfect freedom of motion and security to life.

Some of the bones, such as those which compose the skull and the socket for the eye, are designed exclusively for the protection of important organs contained within them. But by far the greater number are constructed with a direct reference to voluntary motion, and serve only incidentally the purpose of protection.

Fig. 6.



In proportion to the variety of movements which any piece of mechanism is required to perform, its component parts must be numerous and varied. Considered in this light, the animal frame is the most wonderful of all combinations of machinery. No production of art can be compared with it for the multiplicity and nicety of its evolutions; and yet all these are executed simply by muscular power, acting upon the bones or other parts, and changing their relative positions.

The incalculable variety of movements required from man, is the reason why the bones composing the skeleton are so numerous (as may be seen from fig. 6), amounting to about 260, and each so admirably connected with the others by articulations, constructed so as to admit of precisely that kind of motion which the animal requires from it, and of no other. The advantages of this arrangement are not less obvious than admirable. Had the osseous frame-work consisted of one entire piece, not only would man and animals have been incapable of motion, but every external shock would have been communicated undiminished to the whole system. Whereas, by the division of its parts, and by the interposition of elastic cartilages and ligaments at the joints, free and extensive motion is secured, and the impetus of every external shock is deadened in its force and diffused over the body, in the same way as, to a person riding in a carriage, the jolt of the wheel passing over a stone is diminished by being equally diffused over the whole vehicle, in consequence of the elasticity of the springs. The safety imparted by this arrangement to the delicate and important vital organs, is apt to be lost sight of, from the very smoothness with which it enables us to move along, but it will be perceived if we reflect on the shock given to the whole system by taking a single false step in going up or down stairs. The parts have then no time to adapt themselves to the exigencies of the moment, and to put the proper springs in play for the equal distribution of the impetus. Death has been occasioned by accidents of this kind.

In the young the danger which might arise from a shock is further diminished by the cartilaginous nature of the osseous tissue at an early age; for the growth and formation of the bones bear a relation to the nature and amount of the movements in which they will be called on to take part. "The young lamb or foal, for example, can stand on its four legs as soon as it is born; it lifts its body well above the ground, and quickly begins to run and bound. The shock to the limbs themselves is broken and diminished at this tender age by the divisions of the supporting long bones,—by the interposition of cushions between the diaphyses and epiphyses (the centre pieces and extremities of the bones.) And the jar that might affect the pulpy and largely-developed brain of the immature animal is further diffused and intercepted by the epiphysial articular extremities of the bodies of the vertebræ. We thus readily discern a final purpose in the distinct centres of ossification of the vertebral bodies, long bones, and the limbs of mammals, which would not apply to the condition of the crawling reptiles. The diminutive brain in these low and slow cold-blooded animals does not demand such protection against concussion; neither does the mode of locomotion in the quadruped reptiles render such concussion likely; their limbs sprawl outwards, and push along the body, which commonly trails upon the ground; therefore we find no epiphyses with interposed cartilages at the ends of a distinct shaft in the long bones of saurians and tortoises. But when the reptile moves by leaps, then the principle of ossifying the long bone by distinct centres again prevails, and the extremities of the humeri and femora long remain epiphyses in the frog" (that is, are separated by cushions of cartilage from the shaft of the bone.)*

Bones consist of two kinds of substances, viz., those of an animal and those of an earthy nature. To the former belongs every thing connected with the life and growth of bones, and to the latter are owing the hardness and power of resistance by which they are characterized. The primitive basis or original structure of bones is a transparent glary fluid, which gradually assumes a cartilaginous character from the appearance in it of numerous small, sub-elliptic, nucleated cells. As the cartilage hardens, these cells increase in number and size, and are arranged in linear series where ossification is about to commence; which process depends on the power of the cells to separate from the blood the osseous matter forming part of the inorganic salts of that fluid, and to deposit it according to certain fixed laws.* At birth, many of the bones are, properly speaking, of a cartilaginous nature; but, as ossification advances, a proportionate amount of cartilage is removed, and its place is supplied by earthy particles, which form with the remaining cartilage the homogeneous whole called *bone*. Although, therefore, it is to the softer material alone that vital properties essentially belong, it is usual to speak of the life, the vessels, and the nerves of bones, as if life belonged equally to the earthy and animal portions. This is correct enough in reality, because the union between the earthy and animal tissues is always the product of life, and the parts thus united are, to all intents and purposes, living portions of the body. Insensible as they may seem, the bones thus possess all the attributes of living and organized parts. They are all provided with blood-vessels and nerves, and are constantly undergoing the same process of decay and renovation to which all other living parts are subjected.

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* Owen's Lectures on the Comparative Anatomy of the Vertebrate Animals. Part I. p. 38.

The proportion of cartilaginous and earthy matter varies in different animals, and is in admirable adaptation to their peculiar habits. Thus the bones of fresh water fishes contain more animal matter, and are consequently lighter, than those of fishes which swim in the denser medium of the sea. The bones of the salmon, for instance, contain 60·62 parts of organic and 39·38 of inorganic matter, while those of the cod contain 34·30 parts of the former, and 65·70 of the latter. The thigh bone of man is composed of 31·03 parts of organic, and 68·97 of inorganic matter, and is thus rather denser than the bones of the cod. But the rule that the skeleton of sea-fishes is denser than that of fresh-water fishes, is not of universal application. The shark forms an exception; but here again, when the habits of the fish are considered, the same beautiful harmony appears. "The predaceous sharks are the most active and vigorous of fishes; like birds of prey, they soar, as it were, in the upper regions of their atmosphere, and, without any aid from a modified respiratory apparatus, devoid of an air-bladder, they habitually maintain themselves near the surface of the sea, by the action of their large and muscular fins. The gristly skeleton is in prospective harmony with this mode and sphere of life. To have made their entire skeleton consolidated and loaded with earthy matter, would have been an encumbrance altogether at variance with the offices which the sharks are appointed to fulfil in the economy of the great deep."*

Bones, being in their very nature so hard and durable, may be thought not to require any such supply of nourishment, or to undergo any such change of parts, as we have above alluded to. But if we look for a moment to the advantages consequent upon this order of things, we shall see abundant reason for their being subjected in this respect to the general laws of animated nature.

It is only by means of the processes of growth and renewal that the bones can adapt themselves to the wants and state of the system. If the bones were not endowed with the principle of life, the stature of the infant must have been that of the future man. Or even supposing the osseous system to have grown to maturity, and then remained unchanged, the withered form of old age would necessarily have been oppressed and overcome by the large and massive bones which the vigorous muscles of manhood alone can easily put in motion. Had the bones been created unsusceptible of internal change and unendowed with life, it is obvious that, when broken by accident, they must have remained for ever disunited, and become an incumbrance instead of being an assistance to the animal. But, from possessing blood-vessels of their own to supply them with nourishment, and nerves to give power of action to those blood-vessels, the very irritation of the broken end is made to serve the purpose of increasing the vital powers of the injured parts, and producing that excitement which is necessary for the formation of a new bond of union, and for filling up the gap that would otherwise have remained.

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* For a more detailed account of the formation of bone, see Owen, op. cit., p. 27, et seq.

* Owen, op. cit., p. 147.

In a state of health, the bones are almost destitute of sensibility; and here also the most provident benevolence appears. For, surrounded as they are by the softer and more sensitive parts, these afford them ample protection, while their comparative insensibility enables them to act, for any length of time, without weariness or pain. But when a severe accident occurs to break them asunder, or destroy their texture, we immediately become conscious of them through the pain which then becomes their kindest guardian, and the surest promoter of their recovery. In such circumstances, indeed, nothing can be more truly benevolent than pain. It accompanies that inflammation and vascular activity, without which the work of reunion of the broken parts cannot be accomplished; and is the means of securing the repose and quietude which are essential to the exact adaptation of the parts to each other, and which can be obtained only by causing great pain to follow even the slightest motion. Of such utility is inflammation on these occasions, that when, as sometimes happens, the requisite degree of it, from want of nervous sensibility in the part, does not take place, and the bone remains un-united for many weeks, surgeons are in the habit of using violence to produce the necessary stimulus. In this case, they either rub the broken ends rudely against each other, or introduce an instrument between them, by which pain and irritation may be excited, and thus lead to reunion. On the other hand, if pain did not guard the limb from motion when the process of recovery is going on, the union would be incessantly disturbed by every heedless start altering the relative position of the parts. This, also, is occasionally exemplified in practice. Looking at these facts, it is impossible not to admire the wisdom and the benevolence manifested in the adaptation of the structure of the bones in every particular to the circumstances and occurrences of life.

I have already stated, that, besides a large proportion of earthy matter, which gives them dryness and hardness, bones contain a large quantity of animal matter, which is essential to their constitution. In early life, this cartilaginous matter preponderates, and consequently the bones are then less heavy, more pliable and elastic, and possessed of greater vitality. In old age, again, the earthy parts predominate, sensibility is diminished, and there is a lower degree of life. It is from this difference that bones broken in youth reunite in one-third of the time necessary for their reunion in advanced life.

It is a common opinion that bones are more liable to fracture during frosty weather than at other times; but according to Malgaigne, this supposition is erroneous, and has arisen simply from the number of falls occasioning fractures being then more numerous. According to the same surgeon, it is likewise erroneous to suppose that the more frequent occurrence of fractures in old age arises from the dense structure of the bones rendering them more friable. In advanced life, all the tissues of the body undergo absorption, and the osseous tissue forms no exception to this rule, as will be apparent to every one who considers the changes which the lower jaw undergoes in old age. The tissue of the bones certainly becomes more dense, but the bone itself is reduced in thickness, and consequently gives way with a shock which in earlier life it would have withstood uninjured. It should also be borne in mind, that in old age the body falls more heavily, and more like an inert mass, than in youth or middle age, when rapid and energetic muscular action breaks the fall and protects the bones. In early childhood, again, fractures frequently occur before the muscles have acquired rapidity of action, and the bones been consolidated by a sufficient deposit of earthy matter.

In some unhealthy states of the system, the proportion of earthy matter is abnormally diminished, and in some parts it is even altogether removed. The bones become so soft, compressible, and incapable of affording protection or support to the other parts, that instances have occurred in which the lower extremities could be twisted behind as if made of wire. A slighter degree of the same affection is common in weak, rickety children; and hence the deformity of limbs so often occurring from absolute insufficiency of the bones to support the weight of the body. In extreme cases, mere turning in the bed is enough to produce fracture.

Besides the different proportions of organic and inorganic matter in the bones of different animals, and also in different bones of the same animal, according to the various purposes to which they are subservient, we find another beautiful provision adopted for the purpose of combining lightness with strength. The shafts of the long bones are generally formed of a hard dense tissue, almost approaching to ivory, and are much thinner than the extremities, which swell out in order to form the large articular surfaces of the joints, and also to give points of adhesion to the muscles. (See, for instance, the arm and thigh bones, *b b* and *i i*, in fig. 6). But in thus gaining size they lose the dense firm texture of the shaft of the bone, and become cellular and spongy; while their weight, in comparison with their bulk, is proportionally diminished. Moreover, we are taught by mechanical science that a certain amount of matter, in the form of a hollow tube, is capable of supporting a greater weight than the same amount of matter forming a thinner but solid column; and accordingly we find this structure adopted in the shafts of the long bones, which form cylinders, having their cavities filled with marrow, a substance of light specific gravity. In the skeletons of birds, especially birds of flight, every precaution has been adopted to secure extreme lightness. The osseous tissue is exceedingly firm and compact, but its proportional quantity in any given bone is much less than in other animals, and the utmost economy is everywhere traceable in its disposal. "The cavities contain air instead of marrow, and the extremities, instead of being occupied with spongy diploë, present a light open net-work. In the swifts and humming-birds every bone of the skeleton, down to the phalanges of the claws, is pneumatic."*

But the whole structure of birds is so admirably modified to suit their habits, that its study cannot fail to raise within us sentiments of the deepest veneration towards the all-wise and provident Creator. Beginning with the head, we find that teeth are dispensed with, and, as a consequence, along with them the thick and massive jaw-bones into which they must have been implanted, and which are replaced by a light and horny bill. Hence mastication is very limited, and the muscles subservient to this function are proportionally small. Everything thus combines to render the head light, and consequently a long and slender neck is sufficient for its support. Had it been necessary to sustain a massive head at the extremity of a long neck, great muscular development in this region would have been required, and the weight so much increased, as to have materially affected the powers of flight. Moreover, the heavy head at the extremity of the lever of the neck would have deranged the centre of gravity, and in this way also have interfered with flight. For these manifold reasons, then, the masticatory apparatus has been placed in the body of the animal as a gizzard.

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* Owen, op. cit., p. 34.

But various other arrangements for facilitating the flight of birds are observable. They are oviparous, and deposit their eggs one by one as developed; and from the young being so formed that, immediately on chipping the shell, they are ready for the food caught for them by the parents, no milk-secreting apparatus is requisite in the female. Their weight is further diminished by the comparative smallness of the quantity of water necessary for the healthy working of their organism. Hence their urine is secreted in an almost solid state, and their skin possesses no perspiratory glands. Accordingly, the cutaneous functions are comparatively limited; and as they are thus deprived of the means of so fully accommodating themselves to changes of temperature as other animals, migration to colder and warmer climates becomes with many a necessary of life, to which a wonderful instinct accordingly impels them. Lastly, birds of flight are never loaded with fat.*

The practical application to be made of our knowledge of the constitution of the bones, as parts of our animal frame, and as governed by the ordinary organic laws, will now be obvious. Their health we have seen to depend on the regular supply of nourishment by the blood-vessels, on a due supply of nervous energy by the nerves, and on a due balance between the action of the nutrient and absorbent or removing vessels. To the steady fulfilment of these conditions, therefore, we are bound to attend.

It is a common fault to consider the study of an organ or function complete, when we have viewed it on all sides as an isolated part, without regarding its *external relations* as constituting an essential portion of its history. Thus, in the case of the bones, we are apt to describe their hardness, their mobility, and other qualities, without sufficiently adverting to the fact, that, being organs of support and resistance, the frequent and regular performance of a full but not excessive amount of their duties, is as essential to their wellbeing as blood is to the heart, air to the lungs, or light to the eyes. And accordingly, when that condition is not fulfilled, the bones become feeble, diseased, and unfit for their functions, just as the softer parts of the body do. In practice, it is of the utmost importance to be fully aware of this fact.

Medical men are familiar with the fact, that a part deprived of that exercise or action which Nature destined it to fulfil, becomes weakened, diminishes in size, and at last shrivels and alters so much in appearance, as not to be recognizable. Thus, if an artery—such as the large vessel which supplies the arm with blood—be tied, and the flow of blood obstructed, a change of structure immediately begins, and goes on progressively, till, at the end of a few weeks, what was formerly a hollow elastic tube, presents the appearance of a ligamentous inelastic cord. A muscle condemned to inaction is speedily reduced to half its original bulk; and if long unexercised, at last loses entirely its power of contraction and its muscular appearance. The same rule holds with all other parts of the system, and, in an especial manner, even with the hard and apparently unalterable fabric of the bones. It is ascertained by extensive experience, that complete inaction, besides diminishing the size of the bone, injures its structure so much as to deprive it of hardness, and render it susceptible of being cut with a knife. Now, what is strongly marked in the extreme case is not less real, although it may be less palpably apparent, in cases where there is great, though not total, deprivation of exercise; and here we discover one cause of the bad health, crooked spines, and deformed figures, of which the habitual restraint and condemnation to attitude in modern education, lay so wide-spreading and so deep a foundation—evils which could never stand for a moment before knowledge or reason. The bones are the solid framework of the body; and unless they be duly exercised in actual motion, they, like the muscles which move them, suffer and decay in virtue of that universal law which requires the exercise of living organs as the condition of their wellbeing—as the stimulus necessary to their efficient existence.

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* More ample details on this interesting subject may be found in a paper by Carl Bergmann, in Müller's Archiv, part iv. 1850.

To the causes of crooked spine which have already been enumerated, another, dependent on the structure of the spinal column, remains to be added. The spine, it is well known, consists of a series of bones, piled one above another, with plates of cartilage intervening, and the whole firmly bound together by strong elastic ligaments. (Fig. 6, *a a*.) The plates of cartilage are of considerable thickness, but undergo compression from the continued action of any heavy weight —slowly regaining their shape, however, when the pressure is removed. The reality of the compression is sufficiently evident in the diminution of stature which takes place in the course of the day; and the expansion of the cartilages appears in the increase which occurs during the night, when the pressure of the head and upper extremities is removed by our assuming the recumbent position. But if, during the day, the vertebral column be made habitually to lean to one side, the edges of the cartilages on that side undergo an abnormal degree of compression; they gradually lose their elasticity, and cease to regain their normal shape when the pressure is removed. The consequence is, that the spinal column acquires a fixed inclination to one side, and this frequently becomes a permanent distortion.

Dr Herbert Mayo* thus describes one of the most fruitful causes of crooked spine in young girls. It arises, he says, from the habit of assuming, while standing, the posture which gives greatest relief to the languid muscles—that, namely, of "standing at ease," or resting the weight of the body on one limb, and almost always on the right, which is generally the strongest. In such a posture the left hip sinks, and the spinal column, being attached to the pelvis at right angles, of course no longer rises in a perpendicular direction, but inclines to the left. To remedy the leaning of the whole trunk towards this side and the consequent loss of equilibrium which would ensue, the spine in the region of the loins gradually assumes a curve towards the right. But as this flexion, if too long continued, would carry the neck considerably out of the perpendicular, it becomes necessary that the column should again bend towards the left, so as to afford such support to the head as will keep it in the erect position. "This position of rest, this standing at ease, to which children with backs weakened in bone, sinew, and muscle, are prone, and which becomes habitual, brings the spinal column into the following relation to the weight of the body, arms, and head. It is no longer a straight pillar of support, but, so long as the posture is maintained, a flexuous one. That would matter little, if all the elements of the column were strong and rigid. But they are weak, debilitated, disposed to yield, and they give accordingly; and the flexures become, not the temporary yieldings of elastic joints, but permanent givings and yieldings of weakened textures. Once begun, the change can but progress, and the greater the obliquity at each part, the greater the mechanical inability of the spine to resist the growing evil."

One great requisite, then, for the development and health of the osseous system, is adequate and suitable exercise. But whatever matter is the subject, *action* implies waste of materials, and unless this waste be made up by proportionate supplies, exercise leads to speedy decay: this takes place most conspicuously where the exertion has been carried beyond the proper limits, and occasioned a waste beyond what any supply can compensate. A second requisite for the proper state of the bones, therefore, is a sufficient amount of nourishment to counteract the waste which their substance undergoes.*

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* Philosophy of Living, 3d ed.

The effect of exercise in causing the waste of the active organs, is well illustrated by the comparative absence of waste when they are unemployed. *Inaction* implies almost *stagnation*, and is always attended by diminution of the vital functions. This is exemplified, in the extreme degree, in hybernating animals, which pass months in sleep without food, and almost without breathing,—and also in frogs found alive in stones and trees, where they must have been dormant for a great number of years. Inactive parts, then, require little nutrition, because there is little expenditure, and large supplies would be not only useless but detrimental to them.

By a law of the constitution already more than once brought under the reader's notice, and which manifestly bears a relation to this principle, when any part of the system is active, it attracts to itself, by the simple stimulus of that activity, an increased supply of blood and nervous energy. The former repairs the waste of substance which action produces, and the latter gives an increased tone in harmony with the greater call, made on its powers. If the exercise is momentary and not repeated, the extraordinary flow of blood soon disappears, and the nervous power falls to the usual standard. But if it is continued for a time, and is recurred to at regular intervals, a more active nutrition is established: a permanently greater supply of blood enters the vessels, even during the intervals of inaction; and an increase of development takes place, attended with increased facility and vigour of function.

If, again, any part is not duly exercised, there is no local stimulus to attract a large supply of blood or abundance of nervous power; there is no activity of nutrition, no perfection of development, and no vigour of function. And hence, in partial exercise, there is always predominance of some part over others; the one too strong, the other too feeble. In the muscular system, the arms of a blacksmith contrasted with those of a dancing-master, are a familiar illustration.

This law of increased afflux of fluids and increased nutrition to exercised parts, and of diminished afflux and nutrition to inactive parts, is not only highly important in its practical consequences, but is in exact and obvious accordance with the plainest principles of reason. By this benevolent arrangement, parts acting strongly receive large supplies, and parts doing nothing are left in the state of weakness befitting the demands made upon them. To every one who sees the principle, it must appear the height of folly to expect great nutrition and great energy to follow inaction, and *vice versa;* and yet this is what mankind at large, in their ignorance, daily look for.

This law of exercise, as influencing nutrition and function, is universal in its application, and applies to the osseous as much as to any other system. If the bones are duly exercised, then active nutrition goes on, and they acquire increased dimensions, strength, and solidity. If they are not exercised, the stimulus required for the supply of blood to them becomes insufficient; imperfect nutrition takes place; and debility, softness, and unfitness for duty follow in the train. This cause of defective formation is most active and most commonly seen in the bones of the spine in growing girls who are denied free exercise in that part; and the consequent weakness in the bones and cartilages, as well as in the muscles, is a very frequent cause of the swollen joints and curvature in the bones of the limbs in young people, which no subsequent care can ever remove.

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* See the Author's Physiology of Digestion. &c., 9th ed., p. 131.

The beneficial effects of exercise and diet in imparting solidity to the bones, have not escaped the observation of trainers and veterinary surgeons. Sir John Sinclair mentions that the bones of persons trained become, in a remarkable degree, *harder and tougher*, and less liable to be injured by blows or accidents.* Delabere Blaine also, in speaking of the deposit of earthy matter and the consequent consolidation of the bones of the horse being hastened by anything that permanently quickens the circulation through them, remarks that Nature gives to young animals a playful disposition for the purpose of "increasing the flow of blood, and occasioning a more free deposit of the earthy particles." —"The earthy deposit," he continues, "is usually proportioned to the wants of the animal; it is thus most perfect in those whose exertions are most considerable: in the full-bred horse, therefore, the bones will be found more solid than in the bulky lower-bred varieties." But from this very circumstance, when the animal is subjected to premature exertion, the consolidation of the bones becomes more complete before their softer portion has increased to its full dimensions; and hence "horses early and hard worked never arrive at their full size."† Testimony of this kind ought to be of great weight, as based, not on theory, but on the broad and well-marked experience of practical men.

It must be observed, however, that defective nutrition may arise from other causes than inadequate exercise; but even then the consequences attending it are analogous in their nature. Among the poor it often arises from deficiency of wholesome food, and from damp dark habitations; among the rich, from feeble digestive and assimilating powers, and pampering in diet; and also from errors in clothing, and neglect of sufficient ventilation and due exposure to the open air. Rickets, softness of the bones, and white swelling, are accordingly observed to be confined to children belonging to one or other of these classes.*

To understand more clearly the relative uses of bones and muscles, we may be allowed to use a comparison, although, like all other comparisons, it presents many points of difference. The bones are to the body what the masts and spars are to a ship—they give support and the power of resistance. The muscles, again, are to the bones what the ropes are to the masts and spars; it is to them that the bones are indebted for the preservation or change of their position. If the bones or masts are too feeble in proportion to the weight which they are required to sustain, then a deviation from their shape or position takes place; and, on the other hand, if the muscles or ropes are not sufficiently strong and well-braced, then insufficiency of support must necessarily result. Early infancy affords an instance of both imperfections, the bones being infirm, and the muscles small and destitute of true fleshy fibres. The diseased state called *mollities ossium*, or softness of the bones, is an instance of what may be called a weak mast of the body, which must yield if its muscles be strongly drawn. The state of muscular debility consequent on fever and many acute diseases, or even on sudden fright, is, on the other hand, an instance of the inability of the bones alone to preserve an attitude, or execute motion, when the muscular system is weakened by disease. These differences merit attention.

A knowledge of the condition of the bones at different periods of life, is not without its practical uses,—particularly in regulating our treatment of children. In my *Treatise on the Management of Infancy*, I have noticed that many parents, disregarding the fact that the bones are comparatively soft and pliable in infancy,—and in their haste to see the little objects walk without support,—are continually soliciting attempts at standing or walking, long before the bones have acquired sufficient power of resistance, and the muscles sufficient power of contraction, to cope with the law of gravitation. The natural consequence is a curvature of the bone, which yields just like an elastic stick bending under a weight. The two ends approach nearer to each other than they ought to do; and the muscles, to accommodate themselves to the change, become shorter on one side, and perhaps longer on the other, each losing part of its efficiency in the unnatural change which it undergoes.

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* Code of Health, 5th edit. Appendix, p. 35.

† Blaine's Outlines of the Veterinary Art, 3d ed., p. 93.

* See the Author's Physiology of Digestion, &c., 9th ed., chap. xii.

From this view, it will be seen how hurtful leading-strings must be. In the first place, by their mechanical force, they compress the chest and impede respiration; and, in the second place, by preventing the body from falling to the ground, or rather by preserving an upright position, they cause more of the weight to fall on the bones of the spine and lower extremities, than these parts are fitted to carry. From this noxious practice, flatness of the chest, confined lungs, distorted spine, and deformed legs, too often originate.

The impropriety of an indiscriminate use of dumb-bells in early life, will also be easily understood. If the weight of these be disproportioned to the strength of the *bones*, it is obvious that we must produce the same kind of evil as by premature attempts to walk —namely, yielding of the bones, and stretching and relaxation of their connecting ligaments. If, again, they be disproportionate to the muscular power, their effect will be to exhaust instead of increasing the strength of the body.

From the exposition I have given of the laws of exercise, as affecting the muscular and osseous systems, the absurdity of expecting to *strengthen* either the one or the other by the use of stays, or by lying for hours on a horizontal or inclined plane, will be sufficiently manifest. There is no royal road to health and strength,—no method by which, while exercise is dispensed with, its advantages can be obtained. In the intervals between exercise, reclining on a plane is very useful in delicate fast-growing girls; but it should be resorted to only when the feeling of fatigue exists, either from previous exercise, or from mere sitting up. As soon, however, as this feeling is entirely recovered from, it ought to be discontinued, and never employed for hours and days in succession without reference to previous weariness, as it often is, on the false notion of its being conducive to health.

Before concluding this subject, a few general observations may be fitly introduced on the structure of the joints. The bones are articulated in various ways, according to the movements which are required of them; but the principles on which the joints are constructed are the same in all. The articulating surface of every bone is formed of smooth and polished cartilage, covered by a fine and glistening membrane, which secretes the lubricating fluid of the joint. This synovial membrane, as it is called, after spreading out over the articulating surface of one of the bones composing the joint, is reflected forwards to be spread over the articulating surface of the opposite bone, and thus forms an air-tight bag interposed between the extremities of the bones and containing the synovial fluid. The bones are held together partly by the shape of their articulating surfaces, as in the hip-joint, and partly by various powerful ligaments and the tendons of the muscles. Our chief object here, however, is to direct attention to another striking proof of the wisdom with which the human body has been constructed, and to the admirable manner in which lightness is united with strength. The fact was first pointed out by the brothers Weber, that the pressure of the atmosphere, consequent on the air-tight character of the bag formed by the synovial membrane, is of itself more than sufficient to keep the articulating surfaces of the bones in contact. This admirable fact is most readily demonstrated with the hip-joint. The round head of the thigh-bone (fig. 6, *h h*) is received into a socket formed by the os innominatum (*s s*), thus constituting what is familiarly known as a ball and socket joint; and all communication between the cavity of the joint and external fluids is cut off by the synovial membrane. Consequently when, in the dead subject, all the muscles which bind the thigh to the trunk are cut across, and the limb is left suspended to the body by the joint alone, the head of the thigh-bone is retained in the socket by the pressure of the atmosphere. That this is the case may be proved by drilling a small hole through the bone of the socket, so as to admit the air into the synovial cavity; the thigh-bone begins immediately to sink, and dislocation ensues. The power thus exercised by the atmosphere is, of course, dependent on the superficial area of the joint; but Valentin calculates that, in the case of the hip-joint, it is about one-fifth greater than would be necessary to support a limb weighing 30·8 pounds troy, and that the barometer would require to fall to 25 inches to place the limb and the atmosphere in exact equilibrium.* From experiments and calculations made by the same distinguished physiologist, it appears that the pressure of the atmosphere on the shoulder-joint (fig. 3, S) is capable of supporting a weight nearly twice that of the arm, and that the forces thus exercised upon the elbow-joint, knee-joint, and highest joint of the forefinger, are respectively 6 times, 9 times, and 35 times greater than are requisite for the support of the forearm, leg, and finger.† The power thus gained is altogether independent of any additional expenditure of material; and a strength is thus conferred upon many of the joints (for instance, on those of the fingers), which could not have been afforded by mere ligaments, without destroying their elegance and symmetry.

In health the joints are insensible, but when inflamed they become acutely sensitive, and are extremely painful. They are very apt to become affected in gout and rheumatism, owing apparently to the diseased condition of the blood; and in the former disease the synovial fluid frequently deposits chalk or gout-stones in the cavity of the joints, impeding motion, and producing exquisite pain.

In this chapter, as well as in that on the muscles, I have dwelt perhaps too much on the principles by which exercise ought to be regulated; but as the subject is little understood by those who have the direction of youth, and is of permanent importance, I venture to hope that the tediousness of repetition may be forgiven, if clearness and conviction are secured.

CHAPTER IX.

ON THE BLOOD AND THE ORGANS OF CIRCULATION.

In the earlier editions of this work, the next subject discussed was the important function of respiration; but as the chief object of that process is to effect a change in the properties of the blood, it will be useful to give a brief account of the latter, before entering upon the consideration of the changes produced in it during its passage through the lungs.

The blood is the fluid by which the vitality of all other parts of the system is supported, and from which they all derive their nourishment. It is also the source from which all the secretions and excretions are derived, and consequently the medium through which the waste or effete materials are thrown out of the system. Before the food which is taken into the stomach can become a part of the living structure, its nutrient part, which is extracted from it by the organs of digestion, must be converted into blood and distributed throughout the body. It is only when thus converted into blood that the nutriment becomes organized or endowed with living properties, and it is only then that it becomes capable of supporting the life and action of the parts to which it is sent.

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* Valentin's Lehrbuch, vol. i., p. 91.

† Ibid., vol. ii., p. 203.

The blood, therefore, is a compound fluid, containing in a liquid state the elements of all the tissues and organs of the body. When drawn directly from the blood-vessels it is a homogeneous fluid of a bright red or dark purple colour, according as it flows from an artery or a vein. Its colour, however, is not an essential quality; it varies in different animals, and in some of the lowest the blood is almost transparent. In all animals the blood constitutes the nourishing fluid from which all the textures are formed; but in the higher classes it performs another office,—that of conveying into the system the oxygen inhaled in respiration, for the purpose of producing those chemical metamorphoses on which life depends.* If fresh air be prevented from reaching the lungs, or if the blood be so altered in its quality as to be unable to absorb oxygen and convey it into the system, the metamorphoses of the matter within the body are almost as instantaneously arrested, as when a lamp is extinguished by the exclusion of air. The functions of the blood being thus compound, we may naturally expect its substance to be compound also. Accordingly when drawn from an artery or vein and received in a cup, it is observed to separate after a few minutes into a transparent yellowish liquor, called the *serum*, and a firm red coagulum called the *clot*.

The serum consists principally of a solution of albumen in water, along with a small quantity of fatty matter, and part of the inorganic principles of the blood; while the clot is composed of fibrin and the corpuscles or globules of the blood (which can be recognised as such only by means of the microscope), along with some additional fatty matter, and the remainder of the inorganic salts. It is on the fibrin that coagulation depends. In the living blood fibrin exists in a fluid state, but when withdrawn from the body, or after death, it runs into threads or fibres, and hence its name. The living blood, then, consists of a transparent fluid, holding in suspension the globules of the blood, which are small flattened circular discs, forming distinct cells, and considered by some physiologists to be living entities, analogous in some degree to the simplest of the infusory animalcules; they having like them an allotted period of life, and being continually destroyed and continually reproduced.* Hence the blood may be described as consisting of innumerable cells suspended in a glutinous fluid, which has on this account received the name of the intercellular liquid. The globules or cells are formed of thin transparent sacs, enclosing a reddish fluid, the quantity and quality of which are undergoing constant changes through endosmotic and exosmotic action, according to the laws explained on page 44. As a general rule, the deeper or lighter colour of the blood may be said to depend on the greater or smaller number of the globules; but this is not the only cause which gives it different shades, as is at once shewn by adding water to blood. The colour then becomes darker, although the globules are proportionally diminished; and the change arises from the blood-cells assuming a more globular form through endosmotic action, and reflecting the rays of light in a different manner. This experiment is of practical importance, as it shews that a sanguine complexion must not be regarded as an invariable symptom of healthy blood; and Marchand has related a case in which there was externally every appearance of health, but where the globules amounted only to 97 parts in the thousand, instead of 127, which is the average amount in females.† The patient alluded to suffered from a variety of nervous symptoms, every organ in the body seeming to be occasionally affected.

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* See Versuch einer allgemeinen physiologischen Chemie, von G. J. Mulder, p. 356. Heidelberg, 1845.

* See Owen's Lectures on the Invertebrate Animals, p. 365.

† De l'Influence Comparative du Régime Animal, p. 68. Paris, 1849.

When coagulation takes place, the globules become entangled in the meshes of the coagulating fibrin, and thus enter mechanically into the formation of the clot. When, however, from any cause coagulation is delayed, the red globules partially subside before being involved in the meshes, and in this way the so-called buffy coat of the blood is formed, which is simply the pure coagulum of fibrin. On referring to the analyses given below, the reader will perceive that the quantity of fibrin is very small when compared with that of the albumen and globules, scarcely surpassing two parts in the thousand. On this account, and from the fact that fibrin enters very largely into the tissues of the body, it is supposed by many physiologists that the fibrin of the blood is a transition stage between its albumen and the solid tissues; and that it is gradually elaborated from the albumen in the course of the circulation. Under the microscope two distinct kinds of globules may be recognized in the blood, the red and the white, of which the former are by far the most numerous: as, however, it is generally supposed that the white globules are merely the red in a preliminary stage, we shall not draw any distinction between them, but include both under the common term of the globules of the blood.*

The red globules constitute, as we shall afterwards more fully see, the respiratory part of the blood, and are the carriers of oxygen to the remotest parts of the system. They exist in a considerably larger proportion in male than in female blood, as appears from the following analytical tables, deduced, as the average, from several analyses by Becquerel and Rodier. From these it appears that there is contained in 1000 parts of—

	Male Blood.	Female Blood.
Water, .	779·0	791·1
Red globules,	141·0	127·2
Albumen,	69·4	70·5
Fibrin, .	2·2	2·2
Fatty matter,	1·6	1·6
Salts, .	6·8	7·4
	1000·0	1000·0*

When regarded as consisting simply of suspended cells and intercellular liquid, the blood is found to be composed of about equal parts of both. The cells, however, contain considerably more solid matter than the intercellular liquid, the proportion in the former being about 7 parts of water to 3 of solids, and in the latter as 9 to 1.†

From the above table, then, we learn that female blood contains about one-tenth less of the globules than male blood, and that this deficiency is replaced by water; consequently the blood is specifically lighter in women than in men, and hence, no doubt, one of the causes of the superior strength and enduring power of males. That the red globules are those by which oxygen is distributed through the body may be illustrated by reference to experiments by Prevost and Dumas, who found that when an animal is bled almost to death, it can be recovered by injecting into its veins a mixture of the red globules and serum; while the serum alone is quite inadequate to recall life—principally, it would seem, from its not conveying oxygen to the tissues, for Schultz found that when impregnated with oxygen it possessed reviving powers.‡

Within the limits of health, organic activity and the supply of nourishing blood are always proportioned to each other. When a part is sufficiently but not too much exercised, a more vigorous circulation takes place through its vessels, and it increases in size and in power. When it is left inactive, it receives a diminished supply of blood, and becomes comparatively enfeebled. In like manner, when the natural supply of blood to an organ is cut off or diminished, as sometimes happens from tumours pressing upon the principal blood-vessels going into it, its nutrition and its functional power immediately become impaired. As might be expected, similar consequences ensue when the blood itself is imperfectly constituted and inadequate to supply the proper stimulus and the requisite nourishment. This frequently happens among the poor from deficiency of wholesome food; among the rich from an impaired state of the digestive organs; in the consumptive from defective respiration; and in many trades from the impurity of the surrounding atmosphere. The blood cannot nourish unless a due amount of oxygen be supplied to it; and when from violent exercise the metamorphoses of the tissues take place so rapidly as to exhaust the oxygen of the blood faster than it is supplied by the lungs, death is produced. This consequence is seen in animals hunted to death. An opposite condition of the blood may also exist and equally endanger health. From too full living, aided by a good deal of exercise in the open air, which gives keenness to the appetite and vigour to the digestive powers, blood may be formed in so large a quantity, and of so rich a quality, as to keep the system habitually in a state of excitement bordering on active disease, and easily convertible into it by the application of any accidental cause. Many young men, in what may be termed a florid state of health, are thus cut off after a few days' illness, by some acute malady, often to the great surprise of all around them, although obvious signs of danger may have been long present, if the sufferers had only been sufficiently instructed to be able to understand them.

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* Dr Carpenter thinks the production of fibrin is closely connected with the development of the white corpuscles. See his Principles of Human Physiology, 2d ed., p. 508. London, 1844.

* It is impossible to estimate the number of white globules apart from the red with any degree of accuracy, but their number is too insignificant materially to affect these results.

† Lehmann's Lehrbuch der Physiologischen Chemie, 2d ed., vol. ii., p. 152. Leipzig, 1850.

‡ Wagner's Handwörterbuch der Physiologie, vol. i., p. 212.

In these opposite states of diminished and increased vitality, the blood has lost its normal constitution, the changes consisting principally in the diminution or increase of the number of the red globules. In pale sickly girls, on the one hand, where the functions of life are low, they are occasionally reduced to 27 parts in the thousand, while, on the other hand, in stout plethoric young men, where the vital metamorphoses are great, they sometimes rise to 185. Both extremes pass into disease. There can be no doubt that very many of the diseases which afflict mankind arise from a morbid state of the blood affecting the nutrition of the body. We have undoubted examples of this in the eruptive fevers, such as smallpox; but our knowledge of the nature of the changes which the blood here undergoes is extremely limited. We shall bestow some farther brief consideration on this subject when the reader has been made acquainted with the nature of the function of respiration.

From what has been said, it follows that a due supply and proper quality of blood, are indispensable to the life, nutrition, and activity, of every organ of the body; and that, for the continued preservation of health, both the supply and the quality of the blood ought to bear a constant relation to the age, constitution, and mode of life of the individual. In youth, when growth is rapid, and the mode of life characterized by activity, a full supply of well-constituted blood is much more essential than in old age, when growth is at an end, and the bodily energies have become impaired.* In youth, accordingly, the effects of impoverished diet are felt much sooner than in maturity; and hence, in cases of shipwreck and starvation, the young are generally the first to perish.

But the blood, as already hinted, serves other purposes besides those of supporting life and nutrition. It supplies the materials of all the various *secretions*, and, being the medium by which all the decomposed tissues of the body are carried to the various excreting organs, it likewise furnishes the *excretions*; consequently, every secreting and excreting organ receives a supply of blood proportioned to its size, and to the importance and extent of its function. Thus, the urine is separated or excreted from the blood by the kidneys, and these are, in consequence, provided with arteries of a size corresponding to the average copiousness of the excretion. In like manner, the perspiration is derived from the blood, and we have already seen in what profusion the arteries are distributed to the skin. The excretion from the bowels is another example of a similar correspondence. The bland and oily fluids which lubricate the joints, the mucus which moistens the air passages, and the tears which bedim the eye, are all instances of *secretions* derived more or less directly from the blood, and they cease to be formed if the supply of blood to their respective organs be arrested. If, on the contrary, the supply of blood be increased, the organs are stimulated to greater activity; and if the stimulus be carried too far, *diseased* action will follow, and the regular or physiological order of events become interrupted, so that the function may be even altogether arrested.

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* See the Author's Treatises on Digestion and the Management of Infancy.

The greatly increased quantity of blood which is thus directed towards a secreting or excreting organ when in full activity, may be easily conceived from what happens in the case of the kidneys when their function is highly excited. It is a matter of common remark, that a copious discharge of urine often follows within a few minutes after drinking a pint or two of mineral water in a cold morning, or on going into the open air in winter after leaving a convivial party in a warm room. But as every drop of the urine thus rapidly thrown out is derived *from the blood sent to the kidneys*, it is obvious that the whole quantity of blood circulating through them at that time, must have been very large; otherwise no such extensive excretion could have taken place.

The blood which thus supports life, imparts nourishment, and furnishes the materials of the secretions and excretions (with the exception of the bile, which is derived from the venous blood), is called the *vital*, *red*, or *arterial* blood. The first name is derived from its exclusive property of *sustaining life*; the second from *its florid red colour*; and the third from the vessels or *arteries* in which it is contained. It is of this blood we have now to speak.

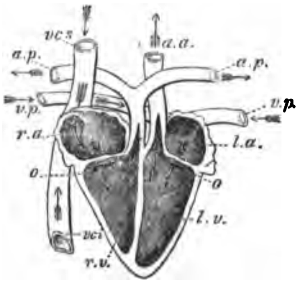
In man and the higher classes of animals, the *arterial* or *vital* blood is of a florid red hue, but in many invertebrate animals it is entirely colourless. The colour also varies in the vertebrate animals, being dependent on the amount of colouring matter contained in the red corpuscles. Thus, it is comparatively pale in the goat and the rabbit, and paler still in the frog and in fishes: hence the light colour of the flesh of these animals. As already mentioned, it is the arterial blood alone which is capable of supporting life and yielding nourishment to the different parts of the organism; and from the moment that it ceases to be supplied to any part, that part begins to decay and die. By the very act, however, of thus supporting life and carrying on nutrition, the arterial blood itself undergoes a change. It loses its bright red colour, assumes a darker hue, and is found to be no longer available for its former purposes. These changes do not occur to any visible extent in the larger arteries, which may therefore be regarded, in a general sense, as serving only for the *conveyance* of the blood. It is in the very minute subdivisions or branches by which the nutrient particles are deposited in the tissues of all living parts, that the change from the arterial to the venous character is first observed.

From the arterial blood being indispensable to the continuance of life and nutrition, it follows that it must, by some means or other, be distributed in due quantity *to every part* of the living body. The solid parts being fixed and immoveable in their respective places, they cannot go in quest of blood, and thus the only alternative is that the blood be brought to them. But it is not sufficient that arterial blood be sent *once* to every organ of the body. The circumstance that in the act of supporting life and imparting nourishment, it loses its own characteristic properties, occasions a necessity that the supply should be *continuous*, and proportioned to the nature and activity of the part. Such accordingly is the fact. The current of vital blood *is* continuous, and ceases only with the extinction of life; and our next step is to investigate the means by which that supply is effected with the regularity and constancy required.

Putting all other questions out of sight for the present, I may mention that the arterial blood is sent as fast as it is prepared to the *left side of the heart*, as the fountain-head from which it is to be distributed through the body. At this point, therefore, we shall take it up.

In Fig. 7, representing a section of the heart, the two sides are seen separated by a white perpendicular line. The letters *v c s*, and *v c i*, indicate the two *venæ cavæ* by which the venous blood is returned from the rest of the body to the *right auricle r. a.* From the right auricle, this venous blood passes by the hole *o*, into the *right ventricle r. v.* It next enters the *pulmonary arteries a.p., a.p.*, to go to the lungs, whence it returns *arterialized*, by the *pulmonary veins v. p., v. p.*, to the *left auricle l. a.* The arterial blood next passes through the orifice *o*, into the *left ventricle l. v.*, to be distributed through the body by the *aorta a. a.* The right auricle and ventricle constitute the *right side* of the heart, and contain *venous* blood. The left auricle and ventricle constitute the *left side*, and contain *arterial* blood. The left ventricle, having the office of distributing the blood for the nourishment of the whole system, is much more muscular and powerful than the right ventricle, which sends the blood through the lungs only. For the sake of simplicity we shall, at present, confine ourselves to the distribution of the arterial blood.

Fig. 7.



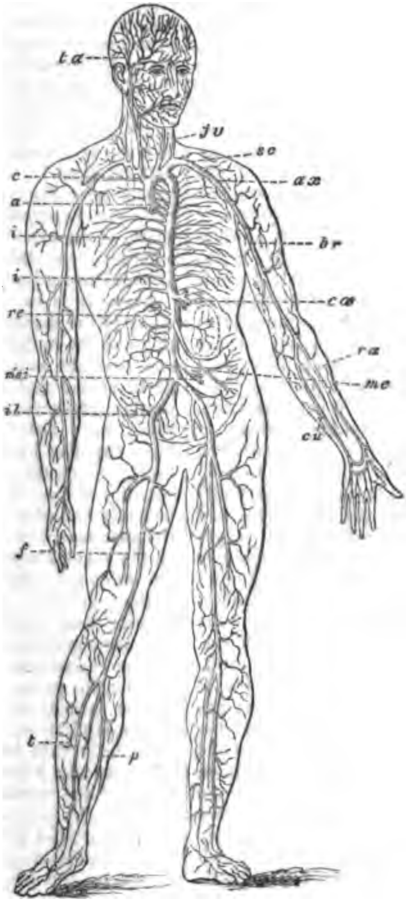
The letters *l. v.*, then, indicate the *left ventricle* into which the arterial blood is poured for distribution. The ventricle, being thick and muscular, contracts powerfully upon the contained blood, and, like a force-pump, projects it into the great artery called the *aorta a. a.* The opening *o*, by which the blood entered the ventricle from the left auricle, being now shut by a valve which admits of the current flowing only in one direction, the blood cannot retrograde in its course; and as another valve at the beginning of the aorta prevents its return into the ventricle from which it has been expelled, the only channel left open to it is that which it actually follows along the aorta.

By every successive contraction of the ventricle, a fresh quantity of blood is projected into the aorta, and it in its turn impels that which preceded it; just as happens with the successive quantities of water raised or propelled by a pump. It is chiefly by this contraction of the left ventricle that the blood is circulated in the arteries; and what is called *the pulse* is merely the successive dilatation and contraction of the arteries as they receive and contract upon every successive quantity discharged by the heart. Hence, in the healthy state, the pulse and the beating of the heart always correspond, and preserve the same relation to each other.

The course of the arterial blood after it has entered the *aorta*, and its gradual distribution through smaller and smaller branches, will be easily understood from the next figure (fig.

8) representing the aorta *a*. just where it leaves the heart, and its various subdivisions as they spread over the whole body. At *a*, just after leaving the heart, the aorta forms a kind of semicircle, which is thence called the *arch of the aorta*. From the upper part of this arch, the arteries supplying the head, shoulders, and arms, are seen to arise and branch into *c* the *carotid*, *s c* the *subclavian*, *a x* the *axillary*, *t a* the *temporal* arteries. At the termination of the arch, the aorta passes downwards along the spine, and gives off branches to the parts lying on each side and to the organs contained in the chest and abdomen, such

Fig. 8.



as *i i*, the *intercostals*, running between the ribs, *cæ* the *cœliac*, going to the digestive organs, *re* the *renal*, going to the kidneys. At the lower part of the spine it divides in two great branches called the *iliac* arteries, *il*, which pass down and subdivide to supply the lower extremities and lower parts of the trunk. The other letters refer to the names of arteries which need not now be particularized.

As the arteries continue, in the manner above represented, to divide and subdivide into smaller and smaller branches, like the branches of a tree from the parent stem, they ultimately reach, in the intimate tissues of the organism, a minuteness which renders them almost invisible, and they become proportionally numerous. To appearance they are even smaller than hairs, and hence they are often called *capillary* (*hair-like*) *vessels*, or branches of the arteries. So minute are they in size and innumerable in quantity, that the point of the finest needle cannot penetrate the skin without piercing them and drawing blood. When, therefore, the expression *capillary vessels* or *branches*, or simply the *capillaries*, occurs, the reader will please to keep in mind that all these are merely different names for the continuous and minute subdivisions of the larger blood-vessels; and when the *capillary circulation* is spoken of, nothing more is meant than that part of the general circulation which is carried on by the minute branches of the larger blood-vessels. Strictly speaking, the capillaries form a kind of network of almost microscopic vessels between what are considered the terminations of the arteries and the commencement of the veins, and are consequently common to both. But in a general sense, the capillary vessels and circulation bear much the same relation to the larger blood-vessels and circulation, which the small gas or water pipes distributed through a private house, do to the main pipes and larger subdivisions extending along the streets and alleys. They are all parts of the same great whole, and the venous capillaries are merely those branches by which the now venous blood is transmitted from the arterial capillaries to the extremities of the veins.

In different organs the capillaries are of different sizes, those of the kidneys, for instance, being considerably larger than those of the skin; and it is not improbable, that upon this difference of structure may depend, to a certain extent at least, the peculiar secretions of the various organs.* We shall afterwards see that the course of the blood in the large blood-vessels is extremely rapid; while, in the capillaries, it is calculated by Valentin to move at the rate of about a yard in half an hour.† If this estimate be pretty near the truth, it will follow that the capillaries are extremely short, as the blood completes the circulation of the whole body in the space of about two minutes.

Since it is in the capillaries that many of the changes incident to nutrition and the support of life take place, and that the arterial blood loses its florid colour and characteristic properties, it follows that if the exhausted blood were not sent away, and its place supplied by fresh arterial blood, nutrition would cease, and death speedily ensue. We have already repeatedly had occasion to observe that the phenomena of life are dependent on the various metamorphoses of matter which are constantly taking place in the organism. It is in consequence of these changes that the arterial blood is transformed into venous, and in this process endosmosis and exosmosis act a conspicuous part. The red corpuscles cannot themselves traverse the walls of the capillaries, but these walls are sufficiently thin to allow a reciprocal action to take place between the contents of the vessel and the juices of the body, by means of which fresh nutritive particles are deposited, and the effete materials carried off to be excreted by the proper organs. We have, therefore, next to shew what becomes of the blood after it has given out the nutrient particles and the various secrétions and excretions already referred to, and thereby lost its vital power.

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* The nature of the secretion is also much influenced by the nature of the cells which constitute the parenchyma or substance of the secreting organ.

† Lehrbuch, vol. i., p. 481.

The principal means which the Creator has appointed for renewing and restoring the lost properties of the arterial blood, are the digestion of food and the process of respiration. By the former, fresh materials of nutrition are supplied in the manner explained in my work on Digestion and Diet; and by the latter, the now dark blood absorbs a portion of oxygen, and gives out the excess of carbon, the presence of which is the chief cause of its being no longer capable of supporting life. But before the digested food can be converted into vital blood, it also must be subjected to the process of respiration; and hence in man and the more perfect animals, the dark blood and the new nutriment must be made to pass together through the lungs or organs of respiration before arterial blood can be formed from them. The next step in the study of the circulation, therefore, is, *to trace the blood from the remote capillary branches of the arteries, where we left it, to the lungs or organs of respiration.*

On carefully examining with a microscope the circulation in the thin membranous web of the foot of a frog, the red blood is seen to pass from the minute arterial capillaries into other vessels equally minute and numerous, which gradually coalesce into larger and larger branches, and these again into others still larger, just as the fine roots of a tree gradually unite, and at last terminate in one common stem. These minute vessels also are termed capillaries; but, from their containing dark blood, they are named *venous*, to distinguish them from the others as *arterial* capillaries. In point of fact, however, the two are continuous, and analogous in structure and appearance. The only differences are, that the blood which they contain is *dark* or *venous*, and that the course which it follows is exactly *the opposite* of that in the arteries. Thus the venous blood proceeds from all parts of the body *towards the heart;* while the arterial, as we have seen, proceeds *from the heart* towards all other parts. The two thus form a current and counter-current; and these two currents constitute what is called the *general, systemic,* or *larger* circulation—the capillaries being merely the small vessels intermediate between the larger branches of the arteries and veins.

Of the course of the veins no particular description need be given, as it is nearly the same as that of the arteries. In most instances, indeed, the deeper-seated veins and arteries lie side by side; but frequently there are two veins where there is only one artery. The more superficial veins, such as those seen on the back of the hand, and on the arm and legs, do not accompany arteries. The branches of the veins, in common with those of the arteries, everywhere communicate freely with each other by what are called *anastomosing* or cross branches; and by this arrangement, when the current is for a time accidentally stopped in one vessel, the blood can always find a passage by another.

The coats of the veins are much thinner than those of the arteries, and consequently are unable to withstand an equal degree of pressure. To obviate the inconveniences which would thus have arisen, especially in the veins of the legs, from the pressure of a considerable column of blood, these vessels are provided with *valves* which prevent the reflux of the current. In a former chapter (p. 98), the influence which muscular contraction exercises on the flow of blood in the veins was taken notice of; and we now farther perceive that, but for the valves, the blood would be driven backwards by the contracting muscle, so as, by distending the coats of the veins, to produce varicose swellings, an affection which, notwithstanding this provision, is frequently seen in those whose occupations oblige them to remain long standing.

From the fact of the blood running

in opposite directions in the arteries and veins, it follows that when a wound is inflicted, a different method must be employed to arrest the loss of blood according as it proceeds from an artery or a vein. If an artery is laid open and red blood is flowing, the pressure or ligature should be applied on the side *nearest the heart;* whereas if a vein is wounded and dark blood escapes, the pressure should be applied on the side *farthest from the heart*, or beyond the wound. We see this principle exemplified in common bloodletting. The object being then to *cause the blood to flow*, the ligature is always placed nearer the heart than the intended puncture of the vein, so as to intercept the current upwards from the hand and fore-arm. When it is wished to stop the flow of blood, the ligature is removed. To those unacquainted with anatomy, the florid or dark colour of the blood which escapes from a wounded vessel will indicate whether it proceeds from an artery or a vein, and whether the chief pressure should be applied above or below the wound.

The object of the dark blood being thus returned to the heart by the veins is, that, after receiving the nutriment prepared from the food in the form of chyle, it may *be transmitted through the lungs, there to undergo the changes required for imparting vital properties to the chyle, and re-converting the venous into arterial blood.* This transmission is effected in the following manner.

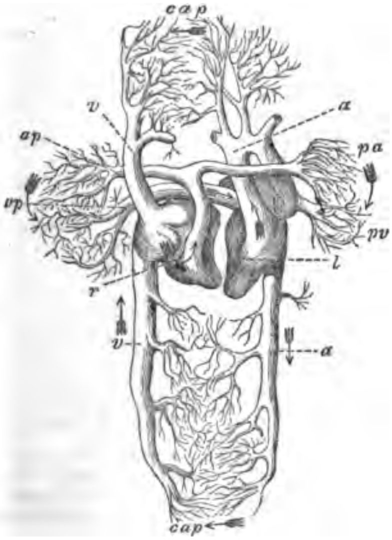
We have already stated that the arterial blood is transmitted by the *left* side of the heart into the aorta for general distribution. By the veins, however, it is returned to the *right side of the heart.* From the head, arms, and upper part of the body, the dark blood returns by a variety of veins, which ultimately terminate in one large trunk called the *vena cava superior* or *descendens* (the superior or *descending* hollow vein), *v c s*, in fig. 7. From the inferior extremities and lower part of the body, the venous blood is returned by a great number of veins which, in like manner, ultimately coalesce into one trunk, called the *vena cava inferior* or *ascendens* (the inferior or *ascending* hollow vein), *v c i*, in the figure. These two great veins are seen to terminate at one common point, where their two currents accordingly meet (as indicated by the arrows), in the cavity termed the *right auricle of the heart*, *r a*. The venous blood, being the proper stimulus of the auricle, causes it immediately to contract, and the necessary result is the propulsion of its contained blood, in the direction of the arrow, through the opening *o*, into the triangular-looking cavity called the *right ventricle*, *r v*. The right ventricle is now in its turn stimulated to powerful contraction, and, as a valve at *o* prevents the return of the blood into the auricle, the current must once more flow, in the direction of the arrow, into the large vessel seen at its upper corner, and called the *pulmonary* (or *lung*) *artery*. This artery divides into two branches, *a.p.*, *a.p.*, one going to each of the two lungs, and spreads through their substance in endless ramifications of infinite minuteness, resembling the capillary vessels already described. These minute capillaries are ramified extensively upon the delicate lining membrane of the innumerable air-cells of the lungs; and it is while circulating through them that the dark blood, by absorbing oxygen from the inhaled air and giving out its carbon in the form of carbonic acid, becomes converted into arterial blood.

To an uninformed person, it may seem impossible that any chemical action should take place between the blood and the external air when the membranous structure of the air-cells is interposed between them. This, however, as we have already seen, forms no obstacle to the requisite changes taking place, for it is found by experiment that venous blood is acted upon by the air even through the thick and firm texture of bladder. Of late years, the researches of Dutrochet and others have shewn that both living and dead tissues give passage to gases and fluids by that peculiar interchange of particles which we described on page 44 under the designation of *endosmosis* and *exosmosis*—processes which play a part in many phenomena previously supposed to be of a purely vital character. Not only, indeed, does the membrane of the air-cells present no obstacle to the changes alluded to, but it also gives passage to a large quantity of watery vapour which is visible in the breath thrown out by the lungs. But as this part of the subject will come to be considered more fully when treating of respiration, I shall now leave it, and proceed to trace the course of the blood onwards to our original starting point.

The venous blood, being thus reconverted into arterial in the capillaries of the air-cells, proceeds onwards into another set of equally minute vessels, corresponding to the venous capillaries of the general circulation. In these the blood is observed to have resumed its florid red colour, and to have changed its direction. It is now transmitted from very minute to larger and larger branches, till the latter at last coalesce, and form the large venous trunks called the *pulmonary veins*, *v.p.*, *v.p.*, in fig. 7. These veins collect all the newly arterialized blood from the two lungs, and convey it to the *left auricle of the heart*, *l.a.*, by the contraction of which it is once more transmitted to the point from which we started, namely, the *left ventricle*, *l.v.*

This transmission of the venous blood from the right side of the heart through the lungs, and back to the left side of the heart in the form of arterial blood, is called *the pulmonic* or *lesser circulation*, to distinguish it from that through the body formerly described as the *general*, *systemic*, or *larger* circulation; and their objects, it will be observed, are quite distinct. The use of the pulmonic circulation is simply to subject the venous blood to the action of the air, whereas that of the systemic is the support and nutrition of every part of the body; and

Fig. 9.



accordingly the lungs themselves receive branches *for their own nutrition* from the vessels of the systemic circulation. There is thus, properly speaking, *a double circulation* in man and the more perfect animals ; and as it is essential that the reader should clearly understand this arrangement, I insert a diagram (fig. 9) in which the two circulations are represented as entirely distinct, and the heart as if consisting of two *separate* halves. In that diagram, the appearance of the heart and the distribution of the vessels are, of course, artificial and different from what is seen in nature, but they will give a correct idea of the distinction between the systemic and the pulmonic circulations.

Starting as before from the *left ventricle, l,* the arterial blood passes into the aorta at *a,* and is thence distributed by the arteries, *a, a,* which branch out as already described till they terminate in the very minute capillary ramifications, *c a p*. These arterial capillaries are seen to join with the equally minute venous capillaries, which coalesce into larger and larger branches of veins, till at length they form the two ascending and descending *venæ cavæ, v v,* which terminate at the *right auricle* of the heart. This includes the whole of the systemic circulation. In the diagram, it is represented by the *upward* and *downward* vessels, and the course of the blood is indicated by the direction of the arrows.

Arrived at the *right auricle,* the venous blood passes into the *right ventricle, r,* from which, as indicated by the bent arrow, it is propelled into the *pulmonary artery, a p* and *p a,* to be distributed to the two lungs. In one sense it is a misnomer to call it an *artery,* as it contains venous blood ; but it has received that name partly from its structure, and partly from its bearing the same relation to the right ventricle which the aorta does to the left, and from its branching out into smaller and smaller ramifications just as an artery does. On arriving at the *pulmonary capillaries,* the venous blood regains its florid colour and life-supporting properties, and is thence collected by the venous capillaries which coalesce into larger and larger branches, and ultimately unite to form the pulmonary veins, *v p* and *p v,* which, as formerly mentioned, transmit the now arterial blood into the left auricle of the heart, and thence into the left ventricle, *l,* from which we started.

Here it is necessary also to explain, that the pulmonary veins, although containing *arterial* blood, take the name of veins from their structure and mode of distribution.

This shorter course is called the *pulmonic* or *lesser* circulation, and in the diagram it is represented by the vessels branching out *horizontally* to the right and left where the lungs are supposed to be. The sole object of this circulation is the aëration of the venous blood, and consequently it varies in the different classes of animals, according to the mode in which the aëration is effected.

The total amount of blood has been estimated by Valentin at about a fifth of the weight of the body ; so that, assuming with Quetelet the average weight of a man, between thirty and forty years of age, to be 170·5 lbs. troy, his blood would amount to about 39 lbs.* If, now, we suppose that the heart contracts seventy times in a minute, and that each contraction propels two ounces of blood, it follows that the whole mass of blood will complete the circulation in three minutes. Valentin† is of opinion that two minutes are sufficient, and other inquirers give even a shorter period. The question is one of considerable difficulty, but an idea of the rapidity of the circulation may be obtained by injecting a solution of prussiate of potash into a vein, and noting the period which elapses before it can be detected in the blood of distant vessels. If the solution be injected into the jugular vein of a horse, the salt may be detected in the blood of the femoral vein in about twenty or twenty-five seconds, thereby shewing that in this almost incredibly short period the blood passes through the right side of the heart — thence through the lungs to the left side of the heart—further, along the whole course of the aorta and part of the arteries of the leg — and finally through the capillaries into the femoral vein. In early life the pulsations of the heart are much more rapid than in mature age. In the new-born infant they amount on an average to 136 in the minute, in the child of nine years to 88, and in the adult to 70. Thus the heart of the adult beats 100,800 times in twenty-four hours, while that of the infant beats 195,840 times. It is worthy of notice that the position of the body has some effect on the number of the pulsations, which are generally 10 or 12 more per minute in a person who is sitting or standing than in one who is lying.

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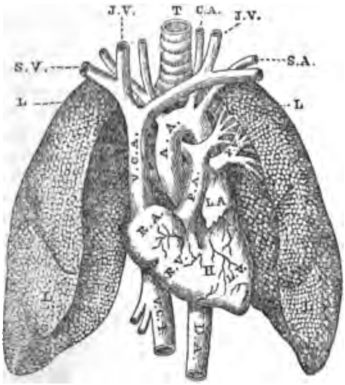
* The quantity of blood is not generally reckoned so high. Weber and Lehmann estimated it at about 8·5 kilogrammes (22·78 lbs. troy) from experiments on the bodies of two beheaded malefactors. See Lehmann, Lehrbuch der Phys. Chemie, vol. ii., p. 259.

† Lehrbuch, vol. i., p. 502.

There still exists among physiologists considerable difference of opinion as to the cause of the motions of the heart; some looking upon its contractions as the result of a reflex action produced by the contact of the blood, while others consider them to depend on nervous power coming spontaneously from the nervous centres of organic life. When the heart of a frog or a fish is cut out and placed upon the table, it continues to beat sometimes for several hours; and this phenomenon shews that its action does not spring from the brain or spinal cord, although we know, from the palpitations produced by mental emotion, that to a certain extent the heart is under the influence of the brain. The weight of evidence at present tends to prove that its motions depend on the stimulus of the blood, which in the excised heart is replaced by the contact of the air; and Tiedemann has shewn that the contractions cease in vacuo, but recommence when air is again admitted:* it remains doubtful, however, whether the contractions are produced by the application of the stimulus directly to the muscular fibres, or indirectly through the medium of the nerves which are enclosed in the muscular tissue. It would far exceed our limits to enter upon the discussion of this question, which moreover is not of that practical character which is the principal object of this work.

Fig. 10.



Having now seen the course of the blood throughout both circulations, the reader will be able easily to understand the prefixed figure, representing the lungs L L L L, heart H, and larger blood-vessels connected with them in nearly their natural situations. The letters L.V. indicate our original starting-point, the left ventricle of the heart, A.A. the aorta, V.C.A. and V.C.I. the venæ cavæ returning the venous blood to the right auricle R.A. and right ventricle R.V. From the upper part of this ventricle, the pulmonary artery P.A. may be traced to the root of each lung. The pulmonary veins P.V. bring the blood back from the lungs to the left auricle L.A., from which it is once more thrown into the left ventricle L.V., to be redistributed and run the same course as before.

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* Müller's Archiv. 1847. P. 490.

It is a curious fact, that in all the warm-blooded animals which have hitherto been made the subject of investigation, the blood is propelled through the arteries with nearly the same degree of force. The strength of the current of the blood has been estimated in various animals by introducing a tube into one of the principal arteries, and ascertaining the height of the column of mercury or water which the pressure of the blood is able to support. According to the experiments of Poiseuille, the force of the current of blood in the arteries of a horse and of an ox, is equivalent to the weight of a column of mercury of about six and one-third inches in height, and in the arteries of a dog to a column of about six inches. From these and other experiments, it is presumed that the blood is propelled in the arteries of man with a force equivalent to the weight of a column of mercury rather more than six inches in height, or of a column of water seven feet high. This force, however, is not constant, but varies with the respiration; increasing with expiration, and diminishing when air is inhaled. Expiration, therefore, assists the heart in propelling the blood; and in accordance with this fact, every one must have remarked how much the pain of headache is increased by a fit of coughing, which tends to augment the flow of blood to the brain. At first sight it may seem improbable that the large and powerful heart of the horse should not propel the current of blood with greater power than the small heart of the dog. But it should be remembered, that the quantity of blood is, in the latter, proportional to the size of the animal, and that hence a smaller heart is required for its propulsion. The heart of the animal is thus always in proportion to the quantity of blood to be propelled, and to the size of the arteries which convey it. When this relation is disturbed, either by increased or diminished power of the heart, the normal condition no longer exists, and a state pregnant with more or less danger supervenes. If the power of the heart be increased, the blood is propelled with a force which may break down the walls of the blood-vessels, especially those of the brain, thus giving rise to apoplexy; while if it be diminished, the body is rendered incapable of undertaking the active duties of life, from the heart being unable to propel the blood in sufficient quantities to sustain the vigour of the various organs. In such cases syncope or fainting not unfrequently arises from the brain receiving an imperfect supply of blood.

When an artery is wounded, the blood springs forth immediately in intermitting jets, caused by the intermitting contractions of the heart, and exerting, as we have seen above, a force equivalent to the weight of a column of water seven feet high. But in the passage of the blood through the capillaries, its intermitting propulsive power becomes equalized, so that when a vein is opened, it no longer springs forth in jets, but flows in a continuous stream. The force of the venous current is much inferior to that of the arterial, scarcely amounting to a tenth of the latter. The principal reasons of this loss of power lie in the arterial force being expended in the passage of the blood through the capillaries, and in the increased channel afforded to the venous blood by the greater number of veins. Hence, when a vein is wounded, it is comparatively easy to stop the effusion of blood by pressure over the wound, as the blood readily passes by another channel. When, however, all the veins of a limb are tied, excepting one corresponding with the artery, the current of the venous blood is nearly as strong as that of the arterial—thereby showing that, in the normal state, the comparative feebleness of the venous circulation is caused principally by the increased calibre of the veins. The reader will now perceive why Nature has been so much more careful in protecting the arteries than the veins from risk of injury, and why it is found so much more difficult to stop bleeding from the former than from the latter.

On the present occasion, it would be entirely foreign to my purpose to enter upon a detailed or scientific investigation of the properties, sources, and uses of the blood. My principal object has been to enable the reader to understand the wonderful mechanism of the heart, by means of which the circulation is unweariedly and uninterruptedly carried on, often for the period of eighty or ninety years, and to give him some general ideas of the manner in which the blood affords the materials for the secretions and excretions. In the next chapter I shall return to this subject in connection with respiration, and meanwhile proceed to offer a few remarks of a general nature on the properties of healthy and diseased blood.

If the term vital can be justly applied to one part of the animal economy more than another, the blood may be said to be peculiarly the *vital fluid* of the body. Not only is it the direct support of life in all other organized parts, but it is the medium by which the external and inanimate matter contained in the food becomes organized and endowed with life. On the proper qualities and due renewal of the blood, therefore, the health and welfare of every living part, and of the system at large, must essentially depend. If, from defective food or bad digestion, the blood be insufficiently supplied with nourishing material to replace its waste, the general health must necessarily suffer, because every organ will then be partially deprived of its healthy support and stimulus. If, from excessive labour, the waste from the system be rendered excessive, and the food be of merely the usual quantity and quality, a gradual deterioration of health will again ensue, because the proper constitution of the blood will be altered. In like manner, if the food be innutritious or unwholesome in quality, the formation of well-constituted blood will cease, and that which is supplied will prove insufficient for the continued preservation of health and life. And again, if the air which we breathe be impure or of an unusual temperature, the proper aëration of the blood in the lungs will be prevented, and the blood, consequently, be rendered partially unfit for its destined purposes in the animal economy, and the health become impaired.

The operation of these various influences is most apparent in the changes produced in the red corpuscles. With good living and deficient exercise, they increase to such a degree as to oppress the system, and render it prone to acute inflammatory disease. With excessive labour and deficient food, on the contrary, they are reduced much below the natural standard, and the organism thus becomes deficient in energy, and liable to take on a morbid action, or to suffer from any injurious influence to which it may be exposed. The fibrin, also, frequently varies from the healthy standard: it is increased in inflammatory diseases, when adhesion between various tissues is consequently apt to be produced; and is altered in quality, and perhaps diminished in quantity, in putrid fevers, scurvy, &c., in which maladies the blood frequently loses its property of coagulation, and acquires the power of traversing the walls of the capillary vessels, sometimes escaping from the surface of the mucous membranes in quantities sufficient to prove dangerous to life. The inorganic elements of the blood are likewise essential to the well-being of the system; for when they are deficient, the bones, and also the other tissues, are inadequately nourished, and rickets and scrofula ensue.

As a general rule, the proportion of the solid materials to the water of the blood is diminished in chronic maladies, and according to Le Canu this is found also to be the case in individuals of lymphatic temperament, when compared with others of more robust constitution. Indeed the experiments of Prevost and Dumas have shewn that the greater the proportion of the solid materials of the blood, the more energetically are the functions of life carried on. In accordance with this observation, it is found that the weight of the clot of an equal quantity of blood is much greater in warm-blooded animals than in reptiles or fishes.

In society, examples of departures from the physiological or healthy standard of the blood unfortunately abound. Among the poor, how many thousands constantly suffer from their blood being impoverished by insufficient food, joined to excess of labour and impurity of air! How many also, even among the rich, have ill-constituted blood flowing in their veins owing to impaired digestion or excess in regimen! Of the influence of innutritious or indigestible food on the qualities of the blood, we have familiar examples in the effects of the prolonged use of salt provisions in producing scurvy and altering the state of all the circulating fluids. The influence of a scanty diet also is visible in the unhealthy condition of the inmates of some of our workhouses. Not to speak vaguely, I may refer to the condition of the children in the West Church Charity-Workhouse at Edinburgh in 1838. Fifty of them, being one-fourth of the whole number, were then afflicted with scrofulous ophthalmia; 17 died consumptive within seven months, and there were 36 cases of fever. An inquiry into the causes of this unusual sickness and mortality proved the evils to have proceeded from inadequate diet and clothing, and an immediate improvement followed a more liberal allowance of food.* A similar instance is mentioned by Mr Combe in his *Notes on the United States of America* (vol. ii., p. 253), when describing the asylum for coloured orphans at New York. Out of between 50 and 60 inmates, no fewer than 15 died within eighteen months, while many more suffered from disease. On examination, these results were found to be chiefly owing to a defective diet; and on this cause being removed, a year passed without the occurrence of a single death! The fearful ravages which the cholera committed in 1849 among the children at Tooting† were also, in the opinion of the medical witnesses, in some measure due to the scantiness of the diet having lowered the tone of their systems. But for the farther elucidation of this subject, I must refer the reader to my work on Digestion and Diet.

Of the deteriorating influence of impure air upon the healthy constitution of the blood, proofs everywhere abound; but as these will be fully considered in the next chapter, when treating of the function of respiration, it is needless to enumerate them here.

Aided by these remarks, the reflecting reader will be able to appreciate the powerful and direct influence which the good or bad condition of the blood exercises upon the general health and vigour. Where, from neglect of the organic laws, the constitution of the blood has become impaired, bad health will never be far distant; and, on the contrary, where all the conditions for the formation of good blood are fulfilled, the greatest facilities which the system can still afford for the recovery of health will undoubtedly be enjoyed. Let those who are not aware of the extent of this influence, consider what occasionally occurs in disease, and they will obtain a more correct idea of the fact. Cases are not wanting, for example, in which women in childbed, apparently at the gates of death from loss of blood, have been resuscitated and ultimately restored to health, by having blood from a healthy person transfused into their veins. In cholera, also—in which the blood almost ceases to circulate, and undergoes a greater change than in perhaps any other disease, being dark and thick even in the arteries—an extraordinary and instantaneous resuscitation has been observed to follow the injection of a largely diluted solution of soda into the veins. In many cases in which this remedy was tried by the late Dr Mackintosh, the patients lay without perceptible sense or motion, almost as if already dead; and yet before the whole of the fluid was injected, they were sitting up in bed talking and apparently well. The effect, unfortunately, was not permanent, for in most of them the fluid was drained off by the bowels in a short time, and collapse again ensued. But it was nevertheless sufficient to shew, in a striking manner, how much the whole animal machine is under the influence of the blood, and how directly it is affected by any change in the qualities of that fluid.

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* Chambers' Edinburgh Journal, 2d and 19th February 1839.

† The establishment contained 1400 pauper children; 300 were attacked and 180 died, and this at a time when no case had occurred in the neighbourhood.

The original formation of well-constituted nourishing blood, and the proper reconversion of venous into life-sustaining blood, are thus seen to be most important processes, not only in the preservation and restoration of health, but in enabling all the organs of the body to work with efficiency and vigour. Even the intellect, the affections, and the dispositions are directly influenced by the good or bad quality of the blood; because the co-operation of the nervous system is indispensable to the action of the mental faculties, and consequently, when the brain is imperfectly sustained by the blood, their tone and activity also become reduced. Many of the anomalous nervous diseases, to which especially females are subject, have their origin in a diseased condition of the blood, generally proceeding from a diminished number of the red corpuscles. Of this fact the blanched lip and pale sickly countenance are sufficient evidence; yet it is not unusual to attempt to remove the headaches which frequently accompany this morbid state, by withdrawing blood by the lancet or leeches, because temporary relief occasionally follows such procedure. No mistake can be greater, as is abundantly proved by the numerous victims who mourn over health thus permanently destroyed. The red globules being the carriers of oxygen, and consequently in a great measure the excitors of vital action, their further diminution by bleeding can only add to the mischief.

On the healthy condition of the blood, then, depends the healthy action of every organ of the body. Convinced of this truth, the reader cannot fail to perceive how pernicious must be the habit of altering its normal composition by the habitual use of large quantities of spirituous liquors. Liquids when received into the stomach are speedily absorbed by the capillary vessels of the mucous membrane, and pass directly into the blood, immediately affecting its composition by the addition of a foreign and abnormal ingredient. Thus altered, it is no longer in a condition to afford healthy nutriment to the various organs, on all of which it exerts an injurious influence, which is however most apparent in its action on the nervous system, from the directness of the effects produced. Ruined digestion, liver-disease, paralysis, weakened intellect, and perverted affections, are among the more frequent results of indulgence in the use of spirits. This subject we shall have occasion to consider when treating of the nervous system; at present it is enough to have shewn how deep an interest we all have in making ourselves acquainted with, and fulfilling, all the conditions required for the formation of healthy blood. Having already in my other work fully discussed those connected with the reception and digestion of the food, it now only remains for me to explain the conditions connected with the important function of respiration. This I shall attempt to do in the following chapter.

CHAPTER X.

THE LUNGS, THEIR STRUCTURE AND FUNCTIONS.—RESPIRATION AND ITS USES.

The word *respiration*, as employed in ordinary conversation, signifies the mere act of breathing, or of inhaling and expelling air from the lungs. But, as often used physiologically, it designates not only the act of breathing, but the whole series of phenomena connected with the conversion of venous into arterial blood. In this latter sense, however, the terms *sanguification* and *aëration of the blood*, also in general use, are more appropriate in themselves; because, while they apply with equal accuracy to all classes of animals, the term *respiration* is almost irrevocably associated in the public mind *with the existence of lungs* —a condition which is so far from being indispensable to the process, that in fishes and many of the less perfect animals, which have no lungs, the aëration of the blood, notwithstanding this want, goes on with the same regularity as in man.

When we consider the variety of circumstances under which the different classes of animals exist, it becomes obvious that the same kind of apparatus could not possibly serve for the aëration of the blood in them all. Lungs, for example, are admirably suited for man, quadrupeds, and birds, which live and breathe in the atmospheric air, and die when immersed in water; but they would be very ill adapted for fishes, which live in water and perish in the air. Fishes, therefore, have no lungs; but, in accordance with their mode of life, they are supplied with *gills*, so constructed as to present a prodigious extent of surface for the necessary ramification of the capillary blood-vessels, and for the exposure of the blood contained in them to the contact of the air which is intimately mixed, in greater or less quantity, with the water in which the animal lives. By this arrangement, the same changes are effected in the venous blood passing through the gills of fishes, as in the venous blood circulating through the lungs in the higher classes of animals. Water is necessary to keep the gill-plates separated and floating, so that the blood may come in contact with the air contained in it; and the reason why fishes die when removed from the water, is simply that then the gill-plates dry and cohere. The power which some fishes possess of existing a considerable time out of the water, depends chiefly on some mechanical modifications of the branchial sacs, which enable them to retain a much larger quantity of water than is usual.*

In worms, again, and other animals of a similar structure, no single organ is set apart for the conversion of venous into arterial blood. The requisite changes are effected in small sacs or vesicles commonly placed in pairs along the back, and opening upon the surface of the body by means of pores in the skin, called *spiracula*, specially adapted to this end, and which cannot be shut or obstructed any more than the real lungs or gills, without inducing death. "In the common earth-worm there are no less than 120 of these minute air-vesicles, each of which is provided with an opening placed between the segments of the body. In the leech, the number is reduced to sixteen on each side, which open externally by the same number of minute orifices." † So necessary, indeed, is atmospheric air to the vitality of the blood in all classes of animals, and even to plants, that its abstraction inevitably induces death. A fish can no more live in water deprived of air, than a man can do in an atmosphere devoid of oxygen. And thus the fish requires a renewal of air, and perishes when it is denied, or when the air is expelled from the water by boiling, exactly as man would do under a similar deprivation. In general, respiration is performed by the circulating apparatus of the blood bringing that fluid in contact with the air in the lungs, gills, or air-vesicles; but in insects we find the relations between the sanguiferous and respiratory systems reversed, and the air distributed by means of a vascular system over the reservoirs of the blood, instead of the blood being distributed over a reservoir of air. This arrangement is rendered necessary by the absence of red globules in the blood of insects. As already explained, these corpuscles perform the office of oxygen-carriers, and accordingly the energy of the respiratory process in the higher animals is proportional to their number. But throughout the whole animal kingdom, we find that vital energy, and activity of the respiratory functions, are constantly associated. Thus, in cold-blooded animals, where respiration is low, the functions of life are proportionally low and languid; while in insects, on the other hand, in which the breathing organs are very fully developed, the vital energies are almost inconceivable. The wings of the common house-fly are calculated to move several thousand times in a second, and even the swallow cannot match the dragon-fly in flight. The latter, says Professor Owen, has been known to elude and outstrip its swift pursuer of the feathered class. The oxygen consumed by insects in motion is accordingly very great, being much more in proportion to their size and weight than in any other animal. A hive of angry bees, from this cause, develope an amount of heat which is really astonishing.

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* Owen's Lectures on the Comparative Anatomy of the Vertebrate Animals, vol. i., p. 260.

† Smith's Philosophy of Health, vol. ii., p. 29.

An apparent exception to the necessity of respiration occurs in the case of the Entozoa, or those animals which exist in other animals. To this class belong the intestinal worms. "But, excluded by the nature of their abode from the immediate influence of the atmosphere, no distinct respiratory organ could be expected to be developed in them. In creatures surrounded by, and having every part of their absorbent surface in contact with the secreted and vitalized juices of higher animals, one might likewise have anticipated little complexity and less variety of organization." * Their respiration, in short, is performed vicariously by the animal in whose interior they live.

In man, the *lungs* are those large, light, elastic, and spongy bodies, which, along with the heart, completely fill the two lateral cavities of the chest. They vary much in size in different persons, and, as the chest is framed for their protection, and moulded on their form, we find it either large and capacious, or the reverse, according to the size which the lungs have attained. The mechanism by which the air is made to enter the lungs, is at once simple and beautiful. The *thorax*, or chest, is a large air-tight cavity, with moveable walls formed by the ribs and intercostal muscles, and closed below by the large transverse muscle called the *diaphragm* or *midriff*, which separates it from the cavity of the abdomen. The ribs (fig. 11, *c c c*) are attached by ligaments to the spinal column *b b*, starting from which they gird the enclosed organs as with hoops, and are fastened in front by cartilages to the *sternum* or breast-bone *a*. By the action of the muscles of inspiration, the ribs and sternum are drawn up, and thus the diameter of the chest, and consequently also its capacity, are increased; while this increase of capacity is aided by the simultaneous contraction of the diaphragm depressing the floor of the cavity of the chest. (See Figures 13 and 16.) It is owing to the pressure exercised on the bowels by the descent of the diaphragm, that the abdominal walls bulge outwards during inspiration. The air rushes in by the windpipe to fill the additional space, and being unable to enter the cavity of the chest except by distending the lungs, it thus inflates them, and keeps them in immediate contact with the walls of the chest. The cessation of the muscular contractions just mentioned, in conjunction with the action of antagonistic muscles, now causes the chest to regain its previous condition, and the inspired air is driven out or expired. This is the mechanical act of respiration in its simplest form; but, under peculiar circumstances, many other muscles besides those commonly designated as the respiratory, combine to carry it on. Occasionally, indeed, when there is risk of suffocation, almost every muscle in the body is called into violent action, to assist, in some way or other, in the inhalation of air. This is the case, for instance, in asthma—in the severe paroxysms of which every muscle seems strained, either directly to expand the chest, or indirectly to aid in its expansion by giving fixed points for the action of other muscles.

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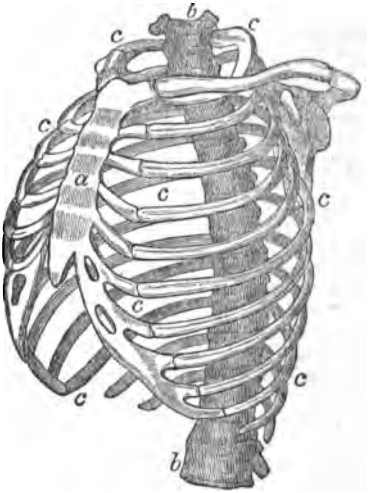
* Owen's Lectures on the Invertebrate Animals, p. 43.

Fig. 11.

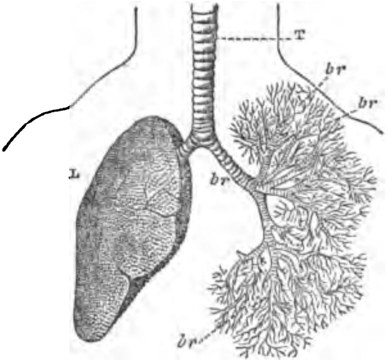


In women and in young persons, the lungs are less developed than in men and adults, and hence the smaller breadth of shoulder and greater narrowness of chest by which the former are characterized.

In fig. 10, page 151, we have already seen the external appearance of both lungs, and the position which they occupy relatively to the heart and large blood-vessels. The substance of which they are composed, consists of *bronchial tubes*, *air-cells*, *blood-vessels*, *nerves*, *exhaling* or *excreting vessels*, *absorbents*, and the areolar membrane or *parenchyma* which binds all these parts together.

The appearance and distribution of the *bronchial tubes*, or *bronchi*, will be understood from fig. 12, in which the right lung L is represented in its natural situation in the right cavity of the chest; while on the left side the substance of the lung is supposed to be removed, leaving only the *bronchi* (*br*, *br*, *br*, *br*). On following the windpipe or trachea T downwards from the neck, we find it first dividing into two large branches, one going to each lung, and then subdividing into the innumerable ramifications *br*, called the bronchi. The bronchial tubes, then, are merely the minute subdivisions of the windpipe; and their purpose is to convey the air from it into the air-cells of the lungs.

Fig. 12.



The *air-cells* are very minute rounded vesicles or bags, smaller than pinheads, in which all the minute ramifications of the bronchial tubes terminate. They are so very numerous, that, when fully distended by air, they seem to constitute the chief part of the pulmonary tissue. Keil estimates their number at 174,000,000, and calculates the surface they present to the air as equal to 21,900 square inches. Lieberkuhn rates the latter at 150 cubic feet; and Monro, again, at thirty times the surface of the human body.* The diameter of each air-cell is stated by Hales and other physiologists at the 100th part of an inch. It is very probable that these estimates are incorrect; but the magnitude of even the lowest of them will give the reader an idea how great the number, and how vast the extent of surface, of the air-cells must really be, to warrant such calculations being seriously made respecting them.

Numerous, however, and closely compacted as the air-cells are, they have no direct communication with each other; but, according to Reisseisen, a small artery, with its accompanying vein, goes to each of them, and, by its ramifications upon the fine, thin, continuous membrane with which they are lined, forms upon it a kind of network of capillary vessels; and it is while circulating through these capillaries, that the blood undergoes the change from the venous to the arterial state by its reciprocal action with the air by means of endosmosis and exosmosis.

The bronchial tubes, but not the minute air-cells, are lined throughout by a thin and delicate membrane, the office of which is to produce a mucous secretion, and prevent the canals from being dried up by the constant passage of a current of air. In certain states of the membrane, such as that occurring in the disease called bronchitis, the quantity of mucus is greatly increased, and would speedily obstruct the passage of the air, and produce suffocation, but for what is supposed to be a special provision for its removal. The mucous membranes of the body are all covered by a thin skin, called the *epithelium*, which corresponds to, and is analogous with, the external scarf-skin or epidermis. The nature of the epithelium varies with the nature of the organ which it invests. In the respiratory passages it is composed of an innumerable quantity of fine pellucid blunt processes, about 1-5000th of an inch long, which, in the living animal, are in a state of incessant vibration, waving backwards and forwards with a lashing movement, and performing at the same time a lateral motion somewhat similar to the feathering of an oar. The result of this action is a current in a definite direction—generally towards the external orifice; and hence the mucus secreted in the small bronchial tubes is by the waving motion of the cilia (as the processes are termed), slowly and gradually propelled into the windpipe, where it acts as a foreign body and produces tickling, which is speedily followed by coughing and expulsion of the offending matter. It is possible that the delicate muscular fibres which encircle the bronchial tubes assist in the propulsion of the expectoration, but the chief part of this office is most probably performed by the cilia. The causes of the ciliary motion are extremely obscure. It is altogether involuntary, and continues for several hours after death, or even after removal of the mucous membrane from the body. Its uses, however, are most important; for, if this motion were annihilated, it seems probable that the secreted mucus would gradually fill up the air-tubes, and thus cause suffocation. Some physiologists are of opinion that the ciliary motion may likewise mechanically promote the chemical changes which take place in the lungs, by preventing the adhesion of a layer of air to the moist mucous membrane, and thus hindering the reciprocal diffusion of the inhaled oxygen of the air and the carbonic acid of the blood; but this view is at least very doubtful, as in the minute air-cells where the oxygen is absorbed and the carbonic acid given off, the epithelium is no longer ciliary, but is then composed of thin flattened scales.

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* Smith's Philosophy of Health, vol. ii., p. 48.

Blood-vessels necessarily form a large constituent portion of the substance of the lungs. Besides the arteries and veins which the lungs possess in common with other parts for the purposes of nutrition, they have, as we have seen, the large pulmonary arteries and veins, dividing everywhere through their substance into innumerable branches, which convey *the whole blood of the body* to and from the capillaries of the air-cells. Indeed, from the rapidity with which the blood performs its circuit through the body, in about two minutes, and the quantity which consequently passes through the lungs in a given time (being certainly not less than *ten pounds in a minute*), it is clear that the vessels of these organs *must* be so large as to constitute no small portion of their tissue; otherwise such a mass of blood could not flow through them so quickly.

The movements of respiration are dependent on the nervous stimulus which the respiratory muscles receive from the medulla oblongata, which may accordingly be described as the nervous centre of the respiratory function. We cannot, however, satisfactorily explain in what manner the nervous stimulus is intermittent or alternate; that is, how at one moment it causes the muscles of inspiration to contract, and next moment is directed to those of expiration. At the first glance it would seem probable that the action is of a reflex nature, dependent on the presence of black and red blood alternately in the lungs. We might suppose, for instance, that the venous blood, by means of the pulmonary nerves, intimates to the medulla oblongata the necessity of oxygenation, and that in accordance with this message a mandate is issued to the muscles of inspiration to contract. So also we might fancy the arterial blood to cause the contraction of the expiratory muscles; or, if this action of the arterial blood be questioned, we might suppose expiration to be essentially a physical process, dependent on the chest regaining its previous form by elasticity. But this theory of reflex action is open to serious objections; for experiments on animals shew that respiration continues sometimes for days after section of the pneumogastric nerves, and that violent respiratory efforts continue to be made even after the heart and lungs have been removed from the body. All that we can at present with certainty affirm is, that respiration depends on the integrity of the medulla oblongata and on its receiving a due supply of arterial blood. When these conditions are fulfilled a constant generation of nervous energy takes place, which is discharged in alternate currents into the inspiratory and expiratory muscles. How this is effected remains a complete mystery, and it would serve no good purpose to consider here the many theories which have been brought forward to explain it.

The process of respiration is entirely involuntary, as is evident from its continuing equally whether we are asleep or awake. We are able, it is true, to control to a certain extent the respiratory movements, and this power is the source of much enjoyment to us, for without it we should be incapable of modulating the voice, and speech would become most disagreeably monotonous. The power of control, however, cannot be carried beyond a certain limit. Man cannot by any effort of his will stop respiration and thus put an end to life. The nervous energy which continues to be generated by the medulla oblongata finally accumulates to such an extent as to overcome the barrier opposed by the will, and respiration recommences notwithstanding our utmost efforts to prevent it. It has been assumed by some physiologists that the motions of respiration are kept up by the feeling of the necessity to respire, produced on the extremities of the whole nerves of the body by the venous blood in the capillaries, and conveyed by their trunks to the nervous centres. In this view respiration would still be a reflex action, dependent, not on the presence of black blood in the lungs only, but on its pervasion of the whole system. In support of this theory a remarkable observation by Professor Nasse of Marburg may be quoted.* This physiologist found that when, by pressure on the aorta of a pregnant bitch, arterial blood was prevented from reaching the pups in the womb, these opened their mouths and snapped as if for air; thus shewing, he concluded, that the presence of the venous blood is the stimulus to the respiratory movement. A great deal might be urged both for and against this view; but the discussion would be out of place here, and we shall therefore be content to choose the simpler view, that the respiratory nervous force emanates from the medulla oblongata, and is there produced by the spontaneous action of that organ. In cases of threatening suffocation the assistance of the voluntary muscles is called in to carry on the respiratory movements; and in extreme cases a stimulus seems to be reflected from the medulla oblongata on to the whole tract of the spinal cord, as almost every muscle in the body appears to take a part in the struggle to respire. Should this prove unsuccessful, the functions of the medulla become destroyed by the black blood which now begins to pervade its substance; the mandate to contract ceases to be issued to the muscles, and a state of quiescence succeeds their previous tumultuous action. To recal life at this stage it is necessary to oxygenate the blood by artificial distension of the lungs, so as to impart a fresh stimulus to the medulla. In aiding to effect this purpose, the application of electricity is frequently of the greatest service.

Although, then, respiration is in general automatic, it occasionally becomes dependent in a great measure on voluntary effort, and is so carried on till gradually the voluntary muscles are tired and worn out, and the blood from imperfect oxygenation loses its vital properties. Accordingly, in cases of narcotic poisoning, where the powers of the medulla oblongata are weakened, it becomes of paramount importance by every possible means to keep the patient awake, so that respiration may be assisted by voluntary effort. In such cases death is to be feared from the inability of the medulla to issue a sufficient stimulus to the respiratory muscles; and consequently, if respira-

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* Wagner's Handwörterbuch der Physiologie, vol. i., p. 212.

tion can only be prolonged till the poison is carried out of the system by the excretory organs, the life of the patient is preserved. A failure of involuntary respiration is occasionally seen also in cases "of extreme debility, whether from excessive fatigue or excitement, or from directly depressing or sedative influences, as in adynamic fevers. A person in this state *is too weak to sleep*; for the medulla partaking of the general exhaustion, cannot maintain the respiration without assistance from voluntary efforts. Hence the feeling of oppression and the frequent sighing which banish all repose; or if sleep do occur it is disturbed by startings and fearful dreams, occasioned by the painful sensations of imperfect breathing. * * * A fatal state of sinking has sometimes been removed by the free administration of ammonia, ether, brandy, and other stimulants; but the best proof of their beneficial action is when they procure refreshing sleep, which in itself is a source of renewed power."*

When treating of the skin as the seat of a copious exhalation of waste matter from the system, I mentioned that in this respect the lungs are somewhat analogous to it, as they also are the seat of an abundant exhalation; of which every one must be aware who has observed the clouds of vapour issuing from a horse's nostrils in a cold day. Even when invisible this exhalation still goes on; the proof of which is the familiar test of holding a cool mirror near the mouth of a person apparently dead, to ascertain whether breathing has entirely ceased. The quantity of watery vapour thus exhaled by an adult in 24 hours, has been estimated by Müller, from the average of many experiments, at 7963 grains, or *nearly seventeen ounces*. As a general rule it is equal to about two-thirds of the cutaneous exhalation, but it is naturally dependent on the amount of exercise and on the nature of the food. Chemically speaking, its origin is threefold. It may be derived, firstly, from the water which is introduced as such into the system with the food, or which is absorbed from the air by the lungs and skin; or, secondly, from the water which is formed in the system by the union of the oxygen and hydrogen of the hydrocarbonates* of the food during the metamorphoses which they undergo in the body; or, lastly, it may be derived from the water resulting from the union of the oxygen of the inhaled air with the unneutralised hydrogen of the food. The first source is probably always the greatest; but the second must add materially to the quantity when the diet is composed principally of the hydrocarbonates—and the third also, where much fat or alcohol is consumed, or in cases of starvation, where the oxygen of the air enters into combination with the carbon and hydrogen of the animal tissues. The pulmonary exhalation is thus one of the chief outlets of waste matter from the system; and the air which we expel from the lungs in breathing is hence vitiated, not only by the subtraction of its oxygen, but by the addition of carbonic acid, and of watery vapour and animal effluvia. In some individuals whose bowels are habitually disordered, this last source of impurity is so powerful as to render their breath offensive, and even insupportable, to the bystanders. The presence of these effluvia in a concentrated form, is, in common with perspiration, one of the chief sources of the disagreeable sickening smell which prevails in crowded rooms; and their amount must be far from inconsiderable if reliance may be placed on the experiments of M. Barral, who found that about half of the nitrogen contained in the food is given off in the form of gas and vapour by the skin and lungs.[*] Regnault and Reiset also found that as a general rule small quantities of nitrogen are given off by the lungs, amounting on an average to about ·006 of the quantity of oxygen consumed.[†] Valentin thinks that the pulmonary exhalation bears a certain though not very determinate relation to the weight of the body, amounting to about 1-36th part of its weight in 24 hours.[‡]

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* Williams' Principles of Medicine, 2d edit., pp. 96-98.

* The hydrocarbonates are compounds of carbon with oxygen and hydrogen in the proportion to form water; such as starch, sugar, gum, &c. Their carbon unites with oxygen to form carbonic acid—the oxygen and hydrogen pass off as water.

Absorption takes place very rapidly by the lining membrane of the air-cells, and in general much more easily and rapidly than it does by the skin. When a person breathes an atmosphere loaded with fumes of spirits, of tobacco, of turpentine, or of any other volatile substance, a portion of the fumes is taken up by the capillary vessels of the lungs and carried into the system, and there produces precisely the same effects as if introduced into the stomach: dogs, for example, may be killed by being made to inhale the fumes of prussic acid for a few moments.

The absorbent power of the lungs has recently been turned to practical account in bringing the system speedily under the influence of anæsthetic agents and rendering it for a time insensible to pain. This application of chloroform is one of the greatest boons which practical medicine has conferred upon suffering humanity. It has deprived the surgeon's knife of more than half its terrors, and, judiciously managed, goes far to abolish the pains of parturition. But the same absorbent power from which these benefits are derived, renders the lungs a ready inlet to contagion, miasmata, and other poisonous influences diffused through the air which we breathe. Hence typhus fever is much more easily communicated by breathing the confined and loaded air near the body of the patient, than even by touch. Hence, also, the general safety of the attendants where ventilation is sufficiently observed; the frequent renewal of the air diluting and carrying off the poison.

The *parenchyma* of the lungs is merely the substance which connects all their other tissues and vessels together. It may thus be more intelligibly described negatively than positively. That part of the pulmonary structure which does not belong to the bronchial tubes, air-cells, bloodvessels, nerves, glands, exhalants, or absorbents, is *parenchyma*. So we have parenchyma in the liver, in the kidneys, and in other organs where a similar connecting substance is required.

Having now given a general idea of the structure of the lungs, let us next examine the changes which occur in the constitution of the air and of the blood during the process of respiration, and the conditions upon which these changes depend.

Atmospheric air consists of 79 parts by volume of nitrogen gas, 21 parts of oxygen, and a very small quantity of carbonic acid, amounting, according to Saussure, to not more than 4·15 in 10,000 parts. The proportion of carbonic acid varies, however, in different situations; but any increase beyond 6 parts in 10,000 must be regarded as exceeding the normal standard, and as due to impurity of the atmosphere. The small quantity of ammonia which seems to always present in the air we may here disregard; for however important it may be to vegetation, it can exercise but little if any effect on animal life. Such, then, are the inorganic principles contained in the atmosphere, and such is its composition when in a state of purity. But " the earth, it is well known, is surrounded by an atmosphere of organic matter, as well as of oxygen, nitrogen, carbonic acid, and watery vapours. This matter varies, and is constantly undergoing transformations from organic into inorganic elements: it can neither be seen, weighed, nor measured. The chemists cannot yet test its qualities. Liebig, with all the appliances of the Giessen laboratory, cannot yet detect any difference between the pure air of the Alps and the air through which the hound can tell a hare, a fox, or a man has passed, or the air which observation shews will produce small-pox, measles, scarlatina, hooping-cough, dysentery, cholera, influenza, typhus, plague. These matters may be either in a state of vapour that is elastic or inelastic, or, like water, they may exist in both states. They are most probably in the state of suspension; hang like the smoke in cities over the places in which they are produced, but are spread and driven about like vesicular water in clouds. A stream of aqueous vapour of the same elasticity from the Atlantic, passing over England, is in one case perfectly transparent; in another, mist; in another, rain: so clouds of infectious matter may float over the country, and in one place pass harmlessly, in another (as influenza in London) destroy thousands of lives. The emanations from the living, the graves, the slaughter-houses, the heaps of filth rotting, the Thames, into which the sewers still empty, raise over London a canopy which is constantly pervaded by zymotic matters; in one season this, in another that preponderating."*

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[*] Annales de Chimie et de Physique. February 1849. P. 129.

[†] Ibid. April 1849.

[‡] Lehrbruch, vol. i., p. 539.

The influence of such matters on the health of the community will frequently be made apparent in the course of this work; at present we but indicate their existence.

The *quantity* of air taken into the lungs at each inspiration varies according to the age, constitution, and circumstances at the time. It has been variously estimated at from 15 to 40 cubic inches. Sir Humphry Davy puts it so low as from 13 to 17 cubic inches. Herbst again states, that adults of large stature breathing tranquilly, inspire from 20 to 25 cubic inches, and persons of smaller stature from 16 to 18.† Menzies, on the other hand, who also experimented with great care, estimates the amount at 40 cubic inches. Dr Southwood Smith states, that the largest quantity ever inhaled at one inspiration is nine pints and a quarter. He adds, that the quantity received at an ordinary inspiration without any effort at all, is about one pint* imperial measure; while at an easy inspiration, *free from any great effort*, it amounts to 2½ pints (2d ed., vol. ii., p. 81). Females take in a smaller quantity than males.

The popular notion that the whole of the air is expelled from the lungs at each expiration, is entirely erroneous. Even after forcing out as much as we can, it is calculated that at least 40 cubic inches remain in the air-cells; while, after an ordinary expiration, about 120 inches remain behind. According to Sir H. Davy, the whole quantity of air in the lungs after a natural inspiration, amounts to 135 cubic inches; so that, taking an ordinary inspiration and expiration at 20 inches, the quantity of air remaining in the chest is at least *five times greater* than that expired. Dr Smith estimates the quantity of air remaining at eleven pints. It is by this continuance of the air in the lungs that its requisite action on the blood is rendered continuous, and has time to take place; and also that we are enabled for a time to "hold our breath" when under water, as in diving. Without this stock to continue the oxygenation of the blood, diving would be immediately fatal.

In whales and some other diving animals that breathe air and remain long under water, there is a remarkable provision for the supply of arterial blood to the various organs while the animal is under water. The intercostal arteries and veins are dilated into enormous reservoirs, the first for storing up large quantities of arterial blood, and the latter for receiving it when it has become venous. When therefore breathing is prevented, the vital functions are carried on by drawing on the arterial reservoirs for a supply, and the animal may remain under water till they are exhausted.

In man the average number of respirations in health varies from fourteen to twenty in a minute; but during disease it is often much greater, and sometimes also considerably less.

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* Registrar-General's Report of Quarter ending Dec. 31, 1847, p. 6.

† Müller's Elements of Physiology, second edition, vol. i., p. 812.

* 34·659 cubic inches = 1 imperial pint.

With these data to guide us, we can form a correct idea of the extent to which a constant renewal of the air we breathe is required for the support of life. Taking the consumption of air at each inspiration at even the moderate rate of 20 cubic inches, and rating the number of respirations at only 15 per minute, it appears that, in that short space of time, no less than 300 cubic inches of air are required for the respiration of a single person. But to place this in a still more striking light to the general reader, I shall extract from the excellent work of Dr Southwood Smith (vol. ii., p. 84), the results of some very careful and elaborate calculations made for him by Mr Finlaison, the celebrated actuary, from data communicated to him for the purpose.

Mr Finlaison estimates the fresh air inspired in one minute at 616 cubic inches, or, "as nearly as may be, eighteen pints." In one hour, it amounts to "1066⅔ pints, or 2 hogsheads, 20 gallons, and 10⅔ pints!" In one day, it amounts "*to 57 hogsheads,* 1 *gallon, and 7¼ pints!*"

To this quantity of air are presented for aëration in one minute 144 ounces of blood, being 259½ cubic inches, or nearly an imperial gallon. In one hour, 540 pounds avoirdupois, or 1 hogshead and 1¼ pints; and in twenty-four hours, 12,960 pounds, or 10,782½ pints, or 24 hogsheads and 4 gallons. Or, in other words, "there flow to the human lungs every minute nearly 18 pints of air, and nearly 8 pints of blood;" and "*in twenty-four hours, upwards of* 57 *hogsheads of air*" *are inhaled to oxygenate* " 24 *hogsheads of blood.*"

Since the publication of the last edition of this work, some very able and interesting experiments have been instituted by Mr John Hutchinson to determine the capacity, and also the inspiratory and expiratory power, of the lungs; and the results of these will be found in the *Quarterly Journal of the Statistical Society of London,* for August 1844. Mr Hutchinson first devised an instrument by which it became easy to determine the quantity of air that any individual could expel from the lungs by the greatest voluntary effort, and then proceeded to test the quantity thus thrown out by each of 1152 individuals, belonging to different trades and stations in life, of different ages, and in different states of health. He regarded the result as an indication of the capacity of the lungs. After a lengthened series of experiments Mr Hutchinson conceived he had made the important discovery, that in the healthy state *a direct relation subsists between the "capacity" of the lungs and the height of the individual*; and he declares this relation to be so uniform, that if he be permitted to take a man's height, he can tell the exact capacity of his lungs, and the amount of his inspiratory and expiratory power. These results will, if confirmed, afford a valuable addition to our present means of detecting pulmonary disease in its very earliest stages. The moment any kind of disease attacks the lungs, their capacity begins to diminish; and consequently, whenever we met with a person whose pulmonary capacity fell short of the average peculiar to his height, we might safely infer that disease existed. The subjoined table presents an accurate outline of the results obtained by Mr Hutchinson. In the first column the height is given. The second exhibits the number of cubic inches of air thrown out of the lungs by a forced expiration, and the regularity with which its increase follows the increase of stature. The third column shews the quantities of air which ought to be thrown out as the height increases, assuming Mr Hutchinson's principle to be correct, and calculating the results arithmetically, instead of taking them from actual observation. The very close approximation between the series of results certainly seems to afford a strong confirmation of the soundness of both the data and the principles on which Mr Hutchinson has proceeded; though, as we shall presently see, they cannot be regarded as altogether free from doubt.

Height.		Series derived from Observation.	Series in Arithmetical Progression.
F. In.	Mean F. In.	Cubic Inches of Air.	Cubic Inches of Air.
5 0 5 2	5 1	175·0	174
5 2 5 4	5 3	188·5	190
5 4 5 6	5 5	206·0	206
5 6 5 8	5 7	222·0	222
5 8 5 10	5 9	237·5	238
5 10 6 0	5 11	254·5	254

The general rule deducible from all the experiments, and confirmed by the preceding table, is, that "*for every inch of height between five and six feet, eight additional cubic inches of air at 60° are given out by a forced expiration.*"*

To shew how greatly the capacity of the lungs is impaired by disease, Mr Hutchinson gives another table, contrasting the capacity exhibited by twelve persons in the early stages of consumption, with the mean of the healthy cases of exactly the same stature—the difference, it will be seen, is very striking.

Capacity of Diseased.		Capacity of Healthy.
C. I.		C. I.
113	...	220
105	...	173
128	...	220
100	...	193
100	...	204
136	...	229
115	...	173
130	...	204
120	...	229
140	...	246
110	...	220
135	...	204

In the advanced stages of consumption the comparison stands thus:—

Capacity of Diseased.		Capacity of Healthy.
C. I.		C. I.
59	...	135
89	...	224
108	...	254
70	...	135
80	...	229
75	...	254
34·5	...	245
18	...	183

Mr Hutchinson believes that this method of estimating the capacity of the lungs is calculated to afford valuable aid to life-assurance companies in the detection of disease in applicants for insurance. His results have since been tested by similar experiments by Dr Simon, carried on under the superintendence of Professor Vogel of Giessen. Dr Simon found that the quantity of respired air stood in direct relation to the height of the individual, but that its absolute amount for a given height was considerably less than in the experiments of Mr Hutchinson. This difference of result is probably due to the subjects of experiment used by Mr Hutchinson having been more robust and more powerful men than those experimented on by Dr Simon. In the former instance they were chiefly sailors, soldiers, policemen, and mechanics; in the latter students.* This discrepance, however, shews that the law propounded by Mr Hutchinson, cannot, at least without further inquiry, be relied on as a practical guide by insurance companies; as another element, beyond the mere height, enters into the question, either in the habits of life, or perhaps in the national build of the chest.

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* It is not easy to explain on what principle the height of the body and the capacity of the lungs should be so closely connected, since an increase of stature is frequently due solely to increased length of legs. It is worthy of remark, also, that "capacity of lungs" and "capacity of chest" cannot be regarded as convertible terms, as the cubic contents of the latter bear no invariable relation to the height of the body.

At first sight it would appear that the observations of both experimenters are opposed to the popular idea that the health and strength of the lungs are to be estimated more by their breadth than by their depth. A short man with broad shoulders and vaulted chest is generally considered more robust and more capable of enduring fatigue than a tall man with narrow flattened chest. This may be the case, and yet on a forced expiration more air may be expelled from the lungs of the latter than of the former. The spirometer gives the degree of contraction which the chest is capable of undergoing, and may therefore be useful as an index of the presence or absence of foreign deposits in the substance of the lungs; but it can afford no means of estimating the amount of air inhaled during ordinary respiration. If we suppose that the respiratory muscles in a broad and in a narrow chested man undergo the same degree of contraction, it is evident that much more air will pass into the broad than into the narrow chest; and hence, though with a forced effort a narrow chest may receive more air than a broad one, under ordinary circumstances the latter will obtain the larger supply.

Before entering the lungs, the atmospheric air consists, as we have seen, of twenty-one parts of oxygen and seventy-nine of nitrogen, with a very small trace of carbonic acid. When it is expelled, however, it is found to be greatly altered. In *bulk*, the air expired continues to be nearly equal to that inspired, but observers are now generally agreed that a slight diminution takes place. Its *chemical properties*, however, are much changed, for we find on analysis that about five parts out of the twenty-one of oxygen have disappeared. Of these five parts of oxygen, four are returned in combination with carbon, as carbonic acid;* but one part remains unaccounted for, and is supposed to enter into combination with the unneutralized hydrogen of the food, to form water, and to be excreted in this shape by the skin, lungs, or kidneys. This view derives support from the fact, that when the diet is exclusively animal, and thus contains a large proportion of unneutralized hydrogen,† the oxygen which disappears is always much larger than when the diet consists of the hydrocarbonates—such as starch, sugar, &c.—which contain no hydrogen beyond what is necessary to neutralize the oxygen contained in the hydrocarbonate. Accordingly, when an animal diet is used, about seven-tenths of the inhaled oxygen are exhaled as carbonic acid, while with a farinaceous diet nine-tenths, and sometimes even the whole, of the inhaled oxygen reappear as carbonic acid.‡

The use of the nitrogen in the air appears to be to serve as a convenient medium for the dilution of the oxygen, so as to prevent any undue excitement of the system. Experimental physiologists are, however, pretty generally agreed that, as a general rule, it receives a slight addition to its volume; and this opinion is supported by the fact, that more nitrogen is consumed in the food than can be afterwards detected in the urinary and alvine evacuations. It remains to be decided, however, how much of this nitrogen is given off as such by the lungs, how much as carbonate of ammonia,* and how much is exhaled by the skin and lungs in combination with watery vapour, as those subtle animal principles, which, when concentrated in overcrowded habitations, lower the tone of the system, and produce fever, cholera, and other analogous maladies. When the same air is breathed again and again, its oxygen diminishes, while the carbonic acid increases with each successive act of respiration; till at last, from deficiency of oxygen, the air becomes altogether incapable of sustaining life.

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* Ueber die Menge der ausgeathmeten Luft bey verschiedenen Menschen. Giessen, 1848.

* Carbonic acid consists of 27·65 parts of carbon, and 72·35 of oxygen.

† By unneutralized hydrogen is meant the hydrogen which remains over, after all the oxygen contained in the food has received the hydrogen it requires to form water. In the case of the hydrocarbonates, all the hydrogen they contain is required for this purpose; in the case of flesh and fat a considerable surplus remains.

‡ Recherches Chimiques sur la Respiration, par MM. Reynault et Reiset; Annales de Chimie et de Physique, July and August 1849.

Precisely the same changes occur in the case of fishes, and of animals breathing by spiracula opening on the surface of the body. The air contained in the water passing through the gills of fishes, loses its oxygen and acquires carbonic acid. The same alteration takes place in the air expelled from the air-vesicles of the worm or the leech. In every class of animals, from the highest to the lowest, the presence of oxygen in the fluid which they breathe is thus essential to the continuance of life, and on the quantity of oxygen consumed depends the energy of their vital functions. Thus, a warm-blooded animal consumes, weight for weight, twelve or fifteen times more oxygen than a frog or lizard; and a marmot consumes, in its lively state, nearly thirty times more oxygen than during its state of hybernation.† Hence the name of *vital air*, by which oxygen is distinguished from carbonic acid or *fixed air*, which has the property of causing almost immediate death when inhaled into the lungs.

It may be thought that if oxygen be really the life-sustaining part of the atmospheric air, life should go on better by increasing the proportion of it in the air we breathe, and that invalids might therefore be restored to health by causing them to inhale a highly oxygenated air. To a certain extent the inference is just; and accordingly we find that an animal placed in a vessel full of pure oxygen, breathes with greater energy, and lives longer, than in the same bulk of common air, in the proportion of fourteen minutes to six minutes.* But as the function of respiration, and all the processes connected with it, were originally instituted by the Creator with relation to an atmosphere containing only one-fifth part of oxygen, the excitement in the animal economy, caused by breathing the latter gas in its pure state, is far too great to admit of its being continued for any length of time, without inducing disease and the ultimate extinction of life. Similar results follow, although more slowly, even when the proportion of oxygen in common air is only partially increased.

In some of the experiments of Reynault and Reiset, it was found that no more carbonic acid was given off by an animal breathing pure oxygen, than by one respiring atmospheric air; and from this fact Liebig concludes that no abnormal excitement is produced by the respiration of oxygen. According to his views, there is formed in the system a certain amount of carbonic acid (greater or less according to the work performed), which is conveyed to the lungs in the red globules of the blood, and is there exchanged for oxygen, according to the laws which regulate the diffusion of gases. The quantity of oxygen absorbed, then, depends not on the amount of oxygen contained in the air, but on the quantity of carbonic acid brought to the lungs for exchange; and the process of diffusion, or of endosmosis and exosmosis, is interfered with only when the oxygen of the air is insufficient to replace the carbonic acid. The process of diffusion is more particularly disturbed when carbonic acid is already contained in the air, and the experiments of Lavoisier and Seguin have shewn that when the atmosphere becomes charged with 10 per cent. of this gas, no additional respiration increases the quantity. The gases within and without the red globules are in equilibrium; and exhalation of carbonic acid being thus entirely suppressed, death takes place by asphyxia. An atmosphere of pure oxygen supports life longer than common air, because in this case longer time is required to produce the state of equilibrium. Regnault's and Reiset's experiments, however, are scarcely sufficient to warrant the assumption that an atmosphere of pure oxygen would not prove deleterious to the animal organism by being too exciting. When we make several deep and hurried inspirations, we feel a confusion and giddiness in the head, which is probably caused by super-oxygenation of the blood. Besides, although, according to the laws of diffusion, oxygen can be absorbed only in proportion to the carbonic acid given off, it is probable that a pure oxygen would in many ways increase the vital metamorphoses, and in this indirect manner increase the quantity of carbonic acid. The whole economy of nature is arranged with reference to the present constitution of the atmosphere, and were the latter to consist of pure oxygen, it would be impossible to prevent, even for one day, a conflagration that would consume every oxydisable substance.

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* About three grains of carbonate of ammonia are given off by the lungs in twenty-four hours.—Liebig and Kopp's Report, vol. i., p. 298; vol. ii., p. 150.

† Annales de Chimie et de Physique, April 1849, p. 442.

* Smith, p. 68.

The only kind of air, then, which is calculated to sustain animal life in permanent health and vigour, is that containing the precise ingredients in the precise proportions ascertained to exist in the atmosphere. If the quantity of any ingredient be increased or diminished, the proper constitution of the blood will be immediately changed, and the general health endangered. If, for instance, the air contain more carbonic acid than the minute trace of it which exists in pure air, it will be to that extent unfit for the purposes of respiration, and act deleteriously upon the blood and general system. This effect is exemplified in the feebleness, headache, and other symptoms, produced by breathing air vitiated by the carbonic acid poured out from several hundred pairs of lungs in a crowded room or church. When the quantity of carbonic acid in the air amounts to 10 per cent., it acts, on the principles already explained, as an immediate poison, and renders the air incapable of supporting life. Hence the fatal accidents so common in breweries, from the workmen rashly entering fermenting vats filled with fixed air. Hence also the immediate insensibility of dogs and other animals thrown into the stratum of fixed air, which occupies the lower part of the celebrated Grotto del Cane, near Naples.

Experiments have been made to determine whether respiration could be carried on by means of any other gas, or mixture of gases, than common air. Some which contain oxygen support life for a longer or shorter time in proportion to its quantity; and those which contain none do not sustain it at all. Nitrous oxide, in which oxygen abounds, may be breathed for a few minutes with comparative impunity, and its intensely exciting effects are well known. Other gases seem to act as direct poisons. Thus, air containing 1-1500th of sulphuretted hydrogen destroys a bird, and 1-800th suffices to kill a dog. This gas is developed from decomposing animal remains, and becomes exceedingly dangerous in close spaces, where it is prevented from being diffused in the atmosphere. Hence it is a frequent cause of death to workmen who descend imprudently into common sewers, before sufficient time has elapsed to allow the noxious vapours to be dispelled. An accident of this kind, in which several individuals lost their lives, happened in a common sewer in Pimlico in the autumn of 1849. Carbonic acid gas, we have seen, also is poisonous, but in a much less degree, and acts by producing narcotism and fatal stupor. This gas is the product of the combustion of carbon or charcoal when oxygen is abundantly supplied; but when the *free* access of oxygen is prevented, another compound of carbon is produced, containing less oxygen than what is found in carbonic acid. This is carbonic oxide, a gas of so deadly a nature, that 1 per cent., mixed with common air, destroys a dog in two minutes. It is the cause of death when suicide is committed by placing ignited charcoal in a close apartment, as is frequently done in France; and it is the occasion, also, of many fatal accidents in our own country, from sleeping in bedrooms where the draught of the chimney is imperfect, and the admission of fresh air is impeded.

The changes effected by respiration in the appearance and constitution of *the blood*, are not less remarkable than those produced on the air. From being of a dark purple hue, it passes immediately to a bright red colour. This change is caused by the action of the oxygen on the red particles of the blood; and it takes place even out of the body when venous blood is exposed to the contact of oxygen. In effecting this change, the oxygen is absorbed, and carbonic acid is exhaled. Arterial blood, accordingly, contains more oxygen and less carbon than venous blood. From the experiments of Mayer, Müller, and others, the arterial blood seems to contain more fibrin than venous blood, in the proportion of 29 to 24; but all such estimates are exceedingly doubtful, partly from the great difficulty of separating the fibrin from the other constituents of the blood, and partly from the venous blood varying in quality according to the organ in which it has been rendered venous. The temperature of arterial blood is believed to be from 1° to 1½° higher than that of venous. But it is in the red globules that the chief changes produced by respiration take place. As already mentioned, these constitute the respiratory portion of the blood, and each globule may be considered as a separate living entity, which comes to the lungs to inhale fresh air. Consequently the greater the number of red globules, the greater is the quantity of oxygen inhaled, and the more energetic are the vital functions. The red globules laden with oxygen are carried along the arteries to the capillaries, where, by means of exosmosis and endosmosis, they deposit their cargo of vivifying material, and becoming venous receive in exchange the expended materials of the tissues, which they convey to the lungs and other organs of excretion. The vast importance of the red globules of the blood for all vital actions will now be manifest, and it will be readily understood why the powers of life are most vigorous in individuals whose blood contains the due proportion of globules, oxygenated by the respiration of a pure, dry, and bracing air; and why, on the contrary, every function is carried on with languor and listlessness when the red globules are deficient in quantity, or the air respired is loaded with impurities.

The change of colour which the blood undergoes is supposed to be, in a great measure, a physical phenomenon, dependent partly on the thickening of the wall of the globule, and partly on a certain change of form which the sac undergoes. The arterial globule is a flattened circular disc with concave sides, which is supposed to reflect the light more abundantly than the convex sides which the globule acquires on becoming venous; and hence the arterial globule appears of a brighter hue from the greater reflection of light. Any substance, therefore, which has the power of thus altering the shape of the globules, changes at the same time their colour, and on this principle is to be explained the florid hue which the solutions of some salts confer on venous blood. This change, however, is by no means identical with that produced by oxygenation; and accordingly, the recommendation of some physicians to inject solutions of these salts into the veins in diseases where the blood is imperfectly oxygenated, rests upon false analogy. But salts do not change the colour of the blood if oxygen be entirely absent, nor do they affect the shade of the colouring matter which has been deprived of its cellular covering.* The circumstance, however, that oxygen effects a change under this latter condition,† shews that the alteration of the colour of the blood is not purely a physical phenomenon.

But in order to ensure the due decarbonisation of the blood, the respired air must be normally constituted; and hence every precaution ought to be taken to ensure its purity by proper ventilation. The experiments of Allen and Pepys have shewn that when air contains an abnormally large proportion of carbonic acid, the decarbonisation of the blood is imperfectly performed, and the expired air carries out of the system less than the normal quantity of carbonic acid. Hence it appears probable that carbonic acid exerts a doubly deleterious action on the organism,—first, by its directly poisonous qualities; and, secondly, by its lowering effects upon the nervous system preventing the proper chemico-vital metamorphoses. Andral and Gavarret have shewn that during the hours of sleep the quantity of carbonic acid eliminated by the lungs is less than during the waking hours. The nervous energy is at this time in a state of comparative depression, and the powers of resistance to injurious influences are consequently lowered. Hence the increased liability to attacks of epidemic disease in the night. "On referring to the experience of cholera in this country," says the General Board of Health, "it appears that the great majority of seizures were between twelve at midnight and six in the morning. In Hamburg the attacks were so generally in the night, that, when the epidemic was at its height, many persons were afraid to go to bed at all; and it is remarkable that the same observation has been made with respect to plague, when it prevails as an epidemic. Dr Laidlaw states, that in his own experience at Alexandria, during the prevalence of plague in that city in 1835, eight-tenths of those who were attacked were seized in the night time—generally early in the morning. 'I do not recollect,' he says, 'to have been called to a fresh case of plague till between five and six in the morning.'"*

This liability to disease during the night is due principally to the lowered tone of the system, resulting from the diminished activity of the function of respiration during sleep, and not to any morbid influence specially appertaining to the hours of darkness. This view is supported by the experiments of Chossat, shortly to be noticed; and also by the fact that travellers traversing the Pontine Marshes in the day-time, and who accidentally fall asleep, though but for a few minutes, are extremely liable to suffer from an attack of ague.

The restoration of the vital properties of the venous blood is not the only change which is effected during its passage through the lungs. The *development of animal heat* is another and very important result of its oxygenation, and one scarcely less essential to the continuance of life. If the human body did not possess within itself the power of generating heat, so as to maintain nearly an equality of temperature in all climates, it could not long exist. In winter, and especially in the northern regions, if no provision existed for replacing the caloric withdrawn from the system by the cold air surrounding it, the blood would speedily be converted into a solid mass, and life be extinguished. In most parts of the globe, the heat of the atmosphere is, even in summer, inferior to that of the human body; and consequently a loss of caloric is always going on, which must be made up in some way, otherwise disease and death would speedily ensue.

The principal source of the heat of the animal body is the combinations into which oxygen enters with the products of the digested food. The nature of these combinations and the amount of heat produced, consequently vary with the quality of the food. In this sense, respiration is essentially a process of slow combustion; carbon and hydrogen are the principal elements consumed, and the amount of caloric produced in the body is precisely the same as would have resulted from the ordinary combustion of these bodies in the open air. In both cases the products are carbonic acid and water.

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* Prof. H. Nasse; Wagner's Handwörterbuch der Physiologie, Band iv., p. 85.

† Lehmann's Lehrbuch der Physiologischen Chimie, Band ii., p. 160.

* Report on Quarantine by the General Board of Health, p. 75.

The amount of heat which oxygen produces in combining with hydrogen is considerably greater than that which the same amount of oxygen produces in combining with carbon.* Hence a diet which is rich in unneutralized hydrogen supports the animal heat better than one in which the material of combustion is solely or almost entirely carbon. Accordingly, we find that an oily animal diet in which hydrogen abounds is that which is preferred in cold countries, while in warm climates the hydrocarbonates chiefly are consumed.† But in the production of the animal heat the state of the blood is an essential element. The red corpuscles being the absorbers and carriers of oxygen (see page 141), where they are deficient the supply of oxygen must of necessity be deficient also, and the vital metamorphoses be imperfectly performed. Accordingly we find, as has been already noticed when describing the blood, that in pale sickly girls, in whom the red corpuscles fall far below the healthy standard, the generation of heat is very imperfect; while it is abundant, almost to excess, in stout plethoric young men. The supply of red corpuscles can be kept up by the digestion of albuminous food only; and here we have another reason, beyond the comparatively large proportion of hydrogen, for the use of an animal diet in cold countries. In general, also, other conditions being alike, the quantity of heat generated is in proportion to the size of the lungs and vigour of the respiration; and when these are impaired, its production is diminished. Hence, many persons with imperfectly developed lungs, and a predisposition to consumption, complain habitually of coldness of the surface and feet; and many who were previously in good health, become more and more sensible of cold, in proportion as the approach of disease weakens the functions of the lungs. I have noticed this increased sensibility to cold, as a precursor of chronic pulmonary disease, both in myself and in others, before any other very obvious symptom had appeared; and I think I have seen its farther progress arrested by the timely use of proper means, where much greater difficulty would have been experienced had the warning not been attended to.

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* The calorifacient power of carbon is 7881, and of hydrogen 33808; that is to say, with equal weights, hydrogen produces above four times more caloric than carbon. But hydrogen requires only ⅛th of its weight of oxygen to form water, while carbon requires 2⅔ of its weight to form carbonic acid. Hence, one part of oxygen in uniting with carbon gives 2950 units of heat, and in uniting with hydrogen 4226 units—a unit being the quantity of heat required to raise a weight of water, equal to that of the body consumed, one degree centigrade. Supposing now, that of the five parts of oxygen absorbed during respiration, four unite with carbon and one with hydrogen, the proportion of heat yielded by the former will be 11,800 units, and by the latter 4226 units; or, the amount of heat afforded by the carbon will be rather more than twice and a half that afforded by the hydrogen.

† There can be no doubt that the principal source of the heat of the body is the direct union of oxygen with the principles of the food or of the tissues of the body; but many physiologists seek additional sources in the friction of the blood against the walls of the heart and the coats of the blood-vessels, in the contraction of the muscles, &c. The amount of caloric produced by the first of these causes has been estimated, on very uncertain data, at about a seventh of that produced by oxidation. (Wagner's Handwörterbuch der Physiologie, Band iv., p. 50.) If, however, we trace back these auxiliary sources of heat to their first cause, we shall find them all originally springing from oxidation; as the overheating of the axle of a locomotive is primarily due to the fire of the engine, though more immediately caused by friction.

The generation of heat in the living system being so immediately connected with the lungs and blood, we find the temperature highest in those animals in which respiration is most energetic and the blood richest in red globules, and lowest under the contrary circumstances. Thus in birds, whose lungs are largely developed, and whose blood contains from 7 to 12 per cent. more of red globules than that of mammals, the animal heat rises in some species to 111·25° F.; while in fishes and reptiles, where respiration is sluggish, and the blood remarkably poor in red corpuscles, the temperature scarcely exceeds that of the medium in which they live.

"The muscular tissue of fishes," says Professor Owen, "is usually colourless, often opaline, or yellowish; white when boiled: the muscles of the pectoral fins of the sturgeon and shark are, however, deeper coloured than the others; and most of the muscles of the tunny are red, like those of the warm-blooded classes. The want of colour relates to the comparatively small proportion of red particles in the blood of fishes: the exceptions cited seem to depend on increased circulation, with great energy of action; and in the bonito and tunny with a greater quantity of blood and a higher temperature than in other fishes."* When the arteries supplying a limb are tied, the temperature of the limb immediately begins to fall; and if the supply of blood be totally cut off, gangrene speedily takes place, because the metamorphoses on which heat and nourishment depend are no longer performed.

It is almost impossible to estimate the quantity of heat generated in the human body; but various calculations have been made with this view, some founded on the quantity of heat which the body is found to impart to water in a given time, and others on the quantity of oxygen absorbed by the lungs. From the latter datum, H. Nasse calculates the quantity of caloric produced by the oxidation of the food to amount in 24 hours to 2,650,000 units; a unit being the quantity required to raise a gramme of water one degree of the centigrade scale. In other words, the caloric generated in 24 hours would raise 100 lb. troy of water from 32° F. to 124° F. The same physiologist calculates that about one-fourth of this heat is lost by evaporation, two-thirds by radiation, and about one-twelfth by what is imparted to the air inhaled in respiration and what is carried off by the evacuations.*

We have seen that the carbonic acid produced by respiration is diminished during sleep. In accordance with this fact, the animal heat produced is observed to be diminished likewise. Chossat, in his experiments on inanition, found that the immediate cause of death in starvation is diminished animal heat, arising from the exhaustion of material with which oxygen could enter into combination, and that the tendency to death was greatest at night when the animal was asleep. That the cause of this tendency was not inherent in anything simply appertaining to the night was evident from the temperature of the animal immediately rising when it was roused from its stupor. In the case of hybernating animals, the temperature falls during the state of torpor, when the function of respiration is almost at a stand, so low as 52° F.; but no sooner is the animal roused, than the functions of life are called into such energetic action, that the temperature rises in a few hours to 94°: and it is worthy of remark, that during this period of awakening, the carbonic acid given off by the lungs very much exceeds the quantity excreted after the animal has attained its natural waking temperature.† An increased expenditure of material is in the first place necessary to warm the body. It is evident, therefore, that respiration is modified in intensity according to the wants of the system; and this fact is further established by the experiments of Letellier,* who found that the consumption of food and the exhalation of carbonic acid is greater in cold than in warm weather,—and by the observations of Vierordt, who remarked that the number and depth of the inspirations diminish with an increase of temperature.† From calculations, founded on the experiments of the last-named physiologist, it appears that an individual excretes above 3 oz. avoirdupois (90 grammes) more of carbonic acid in 24 hours at a temperature of 38° than at 74° F.; a result which would necessitate an additional supply of food, equivalent to nearly half a pound of bread, three ounces of fat, or a pound of flesh, supposing carbon to be the sole calorifacient material.‡

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* Lectures on the Vertebrate Animals, p. 169.

* Wagner's Handwörterbuch, Band iv., p. 74.

† Annales de Chimie et de Physique, August 1849, p. 443.

And here we are again called on to notice one of those beautiful adaptations of the physical laws to the constitution of man. A decrease of temperature is accompanied by a corresponding increase of the density of the atmosphere, and consequently a given bulk of air contains a considerably greater quantity of oxygen in cold than in warm weather. Hence, in cold weather the necessity for increased action of the respiratory organs is proportionally diminished, as the augmented density of the air tends of itself to supply the greater amount of oxygen requisite for the accelerated metamorphoses of the food and tissues. It is a curious fact, and quite in accordance with what we have just stated, that the difference between arterial and venous blood is less marked in summer than in winter. During the former season there is not the same necessity, so to speak, for exhausting the vital powers of the blood.

From what has been said the reader will perceive that the body possesses a self-regulating power, by which it is retained at a uniform temperature, and which acts, partly by increasing or diminishing the expenditure of the fuel (or food) according to the wants of the system, and partly by augmenting or decreasing the evaporation from the skin and lungs. The source of this regulating power lies in the nervous system, which is the appointed and ever-watchful guardian of the wellbeing of the body. For the proper exercise of its functions, the nervous system requires a temperature of 98° or 100°, and the diminution of even a few degrees acts so powerfully and prejudicially upon it that it soon ceases to be able to fulfil its office. Under the diminished temperature the chemical metamorphoses which accompany vital action cease, and the source of heat is thus cut off at the fountain-head. Life is extinguished precisely on the same principle as that according to which a sudden gust of wind extinguishes a candle. In the one case the conversion of the food and tissues into carbonic acid and water is stopped; in the other, that of the tallow; and in both cases the cause of the stoppage of the conversion is the diminution of temperature. Every one must have experienced the difficulty of falling asleep with cold feet. The reason of this seems to be, that the nervous system has, as it were, an instinctive perception that, were its watch withdrawn by sleep, when the vital powers are at any rate lowered, the cause which produces the cold would then act with increased power, and might bring on disease or even destroy life. Hence the resistance which it offers to drowsiness under slight degrees of cold. In cases of exposure to a very low temperature, however, the nervous system becomes itself benumbed, and is unable to resist the approach of sleep, which is then apt to pass into death. All causes that destroy or weaken the sensibility of the nervous system are therefore pregnant with danger when the body is exposed to severe cold, and hence the great risk of having recourse to spirituous liquors under such circumstances. An intoxicated, is more apt than a sober person to perish from cold; and for the same reason drunkards are peculiarly apt to fall victims to whatever epidemic may be prevailing.

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* Annales de Chimie et de Physique, 3me Série, vol. xiii., p. 478.

† Wagner's Handwörterbuch, Band iv., p. 80.

‡ Ibid., p. 83.

As a good illustration of these principles the following anecdote may be quoted:—

"In an excursion in the winter of 1792–3 from St John's to the Bay of Bulls, North America, Captain (the late General) Skinner forming one of our party, we had on our return to cross a large lake over the ice some miles in extent. When about the middle, Captain Skinner informed me that he had long been severely pinched by the cold, and found an irresistible drowsy fit coming on. I urged him to exertion, representing the fatal consequences of giving way to this feeling, and pointing out the state in which his wife and family would be found should the party arrive at St John's without him. These thoughts roused him to exertion for some time; but when he had reached the margin of the lake he gave way and declared he was utterly unable to struggle farther, delivering, at the same time, what he considered his dying message to his family. As there were some bushes near the spot I broke off a branch, and began to thrash my fellow traveller with it; at first without much apparent effect; but at length I was delighted to find that my patient winced under my blows, and at length grew angry. I continued the application of the stick until he made an effort to get up and retaliate. He was soon relieved from the torpor, and as we were now but a few miles from St John's, I pushed on before the party, leaving the captain under special care. I left also the stick with strong injunctions that it should be smartly applied in the event of the drowsiness returning. I soon reached the town, and had some warm porter, with spice, prepared against the arrival of my friends; with this and considerable friction he was enabled to proceed home, where he arrived perfectly recovered."*

There is still another point of analogy between the processes of combustion and respiration, to which, from its important practical consequences, I am anxious to direct the particular attention of the reader. On burning a given quantity of carbon or pure charcoal in a given quantity of air, *they invariably combine in the same proportions and form precisely the same amount of carbonic acid.* For the combustion of 12·7 grains of carbon, for example, 100 cubic inches of oxygen are required, and the result is always 100 inches of carbonic acid. If the portion of air in which the charcoal is burned contain only 75 cubic inches of oxygen, combustion will cease, and 3·2 grains of the carbon will remain unconsumed. If, again, the oxygen exceed 100 cubic inches, the whole of the carbon will be consumed, and the excess of oxygen remain behind. The relative quantities, in short, are fixed and definite, and the results depend directly on the proportions in which they are presented to each other.

In respiration, precisely the same law holds. *Other conditions being alike, a given quantity of atmospheric air, at a given temperature, can oxygenate only a certain and invariable quantity of similarly constituted venous blood.* When the proportion of air is too small, it is unable to furnish the requisite amount of oxygen; consequently a portion of the venous blood remains unchanged, and, becoming mixed with the portion which has been oxygenated, circulates with it, and proportionately impairs its powers of sustaining life and nutrition. When, again, the proportion of oxygen in the inhaled air is artificially made to exceed its due relation to the quantity of blood passing through the lungs, the amount of carbon required to combine with it is wanting, and the excess of oxygen thus absorbed proves so highly stimulating as speedily to disturb the general health. Thus if several deep and rapid inspirations be made, they are followed by noise in the ears and a feeling of excitement in the brain; and the breath may then be held a considerable time, till the super-oxygenated blood has been expended. Dr Southwood Smith calculates that each contraction of the heart propels to the lungs two ounces of blood, and that the proportion of air decomposed by it amounts to 8·5603 cubic inches, or very nearly a quarter of a pint. According to this estimate, as the heart contracts on an average four times for each act of inspiration, it follows that for every time we breathe, eight ounces of blood will be acted upon by one pint of air. But if from any cause the quantity of air entering the lungs be reduced to three-fourths of a pint, or, what is the same thing, if the air inhaled be so impure as to contain only three-fourths of its proper proportion of oxygen, it is clear that the oxygenation of the blood will be incomplete, and that it will be insufficient for the purposes of health.

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* Memoirs of Admiral Brenton. Chambers's Journal, June 16, 1849.

In a sanitary point of view, then, it becomes a matter of great practical importance to determine the amount of fresh air that ought to be supplied to every individual for the normal performance of the function of respiration. In deciding this question, we must consider, firstly, the amount of carbonic acid; and, secondly, the amount of aqueous vapour, formed during the process; for, as we have seen, an atmosphere containing an undue proportion of carbonic acid, and one saturated with moisture, are both injurious to the health. If, now, we suppose that each individual inhales 16 pints of air per minute, and returns four per cent. of the respired air as carbonic acid, we have an hourly consumption of 120 gallons of air, and a formation of five gallons of carbonic acid: 120 gallons of air, then, is the minimum quantity which, according to these data, must be supplied hourly to every individual for the purposes of normal respiration, provided all the carbonic acid is carried off as it is formed; but a much larger supply will be necessary if no measures are adopted for carrying off the carbonic acid—in other words, if there be not perfect ventilation. The proportion of carbonic acid in the atmosphere is, we have seen, about four parts in 10,000; and consequently, if five gallons of carbonic acid be diffused through the air, 5000 gallons will be required to give the proportion of ten parts in 10,000—a proportion more than double the normal, though perhaps not sufficiently great to affect the health injuriously. Hence, though 120 gallons or 19·25 cubic feet would, with perfect ventilation, be a sufficient hourly supply of fresh air to yield the necessary oxygen, an individual would require 5000 gallons, or 802 cubic feet, if shut up in a close room where all renewal of air was impossible, to keep the carbonic acid from exceeding one part in a thousand.

Let us now examine the question from another point of view, and assume that at an average each individual gives off in an hour one ounce and a half of water by the skin and lungs. The breath issues from the lungs at a temperature of 98° F. saturated with aqueous vapour; part of this vapour, by coming in contact with a colder medium, is immediately condensed, and the air becomes loaded with moisture, holding in suspension those subtle nitrogenous principles, which when concentrated act as deadly poisons. The quantity of air necessary to dissolve a certain quantity of water varies with the temperature, but it is calculated that at 59° F. 125 cubic feet of dry air are necessary to dissolve an ounce and a half of water. But if we take the air as already half saturated with water (which may be assumed to be its usual condition in this country), 250 cubic feet will be required to dissolve the same quantity; and consequently this amount of fresh air must be supplied every hour to ensure perfect ventilation, and keep the atmosphere pure and untainted. The foul air must at the same time be carried off. A space containing 2500 cubic feet of air, and receiving no fresh supply, will not serve the purposes of healthy respiration during 10 hours equally well with one containing only 250 cubic feet, but renewed every hour for ten successive hours. In ventilation, therefore, the object must be to remove the foul air as fast as it is formed, and for this purpose a minimum supply of 250 cubic feet of fresh air should be hourly introduced for every individual present. The langour, exhaustion, and headaches, which occur in churches, theatres, and ballrooms, are just so many warnings that ventilation is not properly attended to, that the lungs are insufficiently supplied with oxygen to decarbonise the blood passing through them, and that the system is suffering the evil consequences which such circumstances are fitted to produce.

When these warnings are neglected, and the same air continues to be breathed again and again, the proportion of carbonic acid at last becomes so large that its presence in the inhaled air prevents its further elimination from the blood. It thus acts as a poison, and extinguishes life. This result occurs very speedily when the quantity of carbonic acid in the air reaches the amount of 10 per cent.; but a much smaller quantity, especially when combined with animal effluvia, is sufficient to produce fatal effects when its action is prolonged. The most terrible catastrophe known to have arisen from this cause, is that which occurred in the Black Hole of Calcutta in 1756. One hundred and forty-six Englishmen were thrust into a wretched prison 18 feet square, in which there were only two very small windows by which air could be admitted; but as both of these were on the same side, ventilation was utterly impossible. Scarcely was the door shut upon the prisoners, when their sufferings commenced, and in a short time a delirious and mortal struggle ensued to get near the windows. Within four hours, those who survived lay in the silence of apoplectic stupor; and at the end of six hours, *ninety-six* were relieved by death! In the morning when the door was opened, 23 only were found alive, many of whom were subsequently cut off by putrid fever, caused by the dreadful effluvia and corruption of the air.

But it may be said, such a catastrophe as this could happen only among a barbarous and ignorant people. One would think so; and yet such is the ignorance prevailing among ourselves, that more than one parallel to it can be pointed out even in our own history. Of the instances to which I allude, one is published in the life of Crabbe the poet. When ten or eleven years of age, Crabbe was sent to a school at Bungay. "Soon after his arrival he had a very narrow escape. He and several of his schoolfellows were punished for playing at soldiers, by being put into a large dog-kennel, known by the terrible name of the 'Black Hole;'—George was the first that entered; and the place being crammed full with offenders, the atmosphere soon became pestilentially close. The poor boy in vain shrieked that he was about to be suffocated. At last in despair, he bit the lad next to him violently in the hand; —'Crabbe is dying—Crabbe is dying,' roared the sufferer; and the sentinel at length opened the door, and allowed the boys to rush out into the air. My father said, 'A minute more and I must have died.'"*

Another instance of a very similar kind is mentioned in Walpole's Letters. A parcel of drunken constables, he says, took it into their heads to arrest every body they met, and thrust them into St Martin's round house. Five or six and twenty persons were thus shut up all night with closed doors and windows. In the morning, four were found suffocated for want of air, two died shortly after, and a dozen more were "in a shocking way." A similar but less tragical case occurred but a few years ago at Tain in Ross-shire, where several persons arrested for rioting were almost suffocated by being confined in a small closet that had been used as the *safe* of a bank. But the most fearful instance in modern times, and one rivalling in horror that of the Black Hole of Calcutta, occurred in the Irish steamer "Londonderry," on the night of 1st December 1848, when of 150 passengers, crowded together in a narrow cabin on account of the stormy nature of the weather, not fewer than 70 were suffocated before morning!

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* Crabbe's Life, by his Son, p. 17.

In these deplorable examples of the misery caused by ignorance of the simplest laws of the animal economy, the effects arising from the absence of a due proportion of oxygen in the air inhaled are portrayed in appalling colours. But those which are produced by breathing an atmosphere vitiated to a smaller extent, are, although not so strikingly obvious, by no means less real. God has decreed that a certain proportion of oxygen contained in pure air, shall suffice for the aëration of only a fixed and determinate quantity of venous blood. If we adapt our circumstances to this law, we reap our reward in comfort and health. Whereas, if we neglect it and persevere in breathing an atmosphere loaded with putrefying animal effluvia, and containing less than the requisite quantity of oxygen, with more than the usual quantity of carbonic acid, we have no more right to expect to enjoy health, energy, and activity of mind and body, than to expect a fire to burn without air, or a fish to live out of the water. As an example of the manner in which human life is often sacrificed by the prolonged breathing of an impure air, not sufficiently lethal to produce at once fatal consequences, we may here quote an instructive instance furnished by the Taunton workhouse. "In the beginning of June 1849, a sudden and violent outbreak of cholera occurred in the workhouse of the town of Taunton. No case of cholera had previously existed, nor did any subsequently take place among the general inhabitants of the town, though diarrhœa was prevalent to a considerable extent. The workhouse is badly constructed; the ceilings of the rooms being in general not more than 8 feet 9 inches in height, and the ventilation extremely defective. Into the girls' school-room, a slated shed, 50 feet long, 9 feet 10 inches broad, and 7 feet 9 inches in height to the top of the walls, the roof being sloping, there were huddled 67 children. Each child had, therefore, for respiration only about 68 cubic feet of air. The epidemic influence which was pervading the district struck this establishment. On November 3d, one of the inmates was attacked with cholera; in ten minutes from the time of the seizure, the sufferer passed into a state of hopeless collapse; within the space of 48 hours from the first attack 42 cases and 19 deaths had taken place; and in the course of one week 60 of the inmates had been swept away. A curious circumstance (says Dr Sutherland) occurred with respect to the boys' school. This apartment was rather worse than that of the girls; but the boys, who were good and obedient in other respects, could not be kept from breaking the windows. In the girls' school the windows were never broken; and the chaplain of the workhouse states his firm belief, that it was to the better ventilation, which the broken windows maintained in the boys' school, that the children in some measure owed their lives."* Twenty-five girls died and nine boys, along with their schoolmaster.

Again: "In the county gaol, situated in the same town, the space allowed to each prisoner ranges from 819 to 935 cubic feet; at the same time there passes through each cell a perfect system of ventilation, while a temperature is maintained that hardly varies three degrees in 24 hours. Each prisoner has abundant means of cleanliness. *The inmates of the gaol, though in confinement, being thus surrounded by the appliances of health, escaped without experiencing the slightest touch of the epidemic; while of the* 276 *inmates of the workhouse, no fewer than* 60*; or nearly* 22 *per cent. of the whole number, died of cholera within one week, and nearly all the survivors suffered to a greater or less extent from cholera or diarrhœa.*"†

That the outbreak of cholera in the workhouse, and the escape of the prisoners in the jail, were not mere accidents, sufficiently appears on comparing the mortality of the two establishments during a period of seven years from 1842 to 1848, both inclusive.

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* Report by the Board of Health, on the Epidemic Cholera of 1848 and 1849, p. 37.

† Report, p. 71.

The average number of inmates of the workhouse during each of these years was 315, and the average number of deaths 49, or one in 6·4,—a mortality which must be regarded as excessive, even although it be admitted that a large proportion of the paupers entered the house in a sickly state. During the same period 4940 prisoners passed through the gaol, and of these only 11 died, one being 83 years of age.

Perhaps no other case on record shews more clearly to what extent man has the preservation of health in his own keeping. Here, on the one hand, we have a mortality exceeding that of an hospital for the sick, occasioned, in a great measure, by man's ignorance and neglect of the laws of health; and, on the other, even under the disadvantage of confinement, a degree of health such as is rarely obtained under the most favourable circumstances, but which here was the reward of obedience to these same laws. In domestic and social life, however, they are habitually disregarded to an extent which will appear incredible when the practical benefits of physiology shall be more correctly appreciated, and its innumerable applications be made more extensively known through the ordinary education of the young. To hasten the arrival of this period as far as lies in my power, I shall, in the following chapter, direct attention to a few of the more prominent advantages to be obtained from the regular observance of the laws of respiration, not only in the prevention and cure of disease, but in promoting the moral and intellectual as well as physical well-being and happiness of the race.

CHAPTER XI.

LAWS OF RESPIRATION.—CONDITIONS OF HEALTH OF THE LUNGS.

In the instructive and elaborate Appendix by Mr Farr to the Registrar's *Second Annual Report of Births, Marriages, and Deaths*, it is stated that 27½ per cent. of the total deaths in England and Wales for 1838 were owing to diseases of the respiratory organs, and that of these no less than 59,025 arose from consumption alone. Of that number 31,090 were of females, and 27,935 of males; being in the proportion of 16·0 of males to 19·2 of females. Supposing the deaths from consumption in Scotland and Ireland to bear the same relation to the population as in England and Wales, the total number for the United Kingdom will fall little short of 100,000 annually.

During the eight years 1840–47, the average number of deaths from consumption in London alone was 7030; one death out of every seven being caused by this disease, the total average mortality amounting to 49,734. If now we bear in mind that, taking healthy and unhealthy districts together, about one-third of the population of London is swept away before attaining the age of five years, and that consumption is a malady of comparatively rare occurrence in childhood, it is obvious that its ravages must fall with peculiar severity upon the adult population. Accordingly, we find that about 40 per cent. of the total number of cases occur during the decennial period from 20 to 30 years of age. If any thing farther were required to excite an interest in the investigation of the causes and means of preventing this prodigious fatality, the fact that the young, the amiable, and the gifted are thus carried off in a far higher proportion by consumption than by any other disease, would be sufficient to arouse our solicitude. But I feel assured that the inherent importance of the inquiry will of itself be sufficient to enlist the attention of every reflecting reader.

From the general explanation already given of the structure and uses of the lungs, it will be obvious that several conditions, which it is our interest carefully to study and observe, are essential to the healthy performance of respiration. First among these we may rank *an abundant supply of pure atmospheric air, containing its full proportion of twenty-one per cent. of oxygen, and not more than its due proportion of about four parts in ten thousand of carbonic acid.* Implied in this condition, or at least practically inseparable from it, is another—that nothing shall impede the full play and dilatation of the lungs; so that *at every inspiration a sufficient quantity of pure air shall be received into the air-cells to ensure the due and complete oxygenation of the whole venous blood subjected to its action.* Let us treat of these conditions in succession.

If a mouse be confined under a large glass-jar, full of air, but so arranged that no fresh air can possibly enter, the little creature will not for some time shew any appearance of inconvenience, because as yet the air which the jar contains will be tolerably pure. In proportion as the consumption of oxygen and the consequent exhalation of carbonic acid proceed, it will begin to shew symptoms of uneasiness analogous to those which are experienced by delicate persons in a close and crowded hall. In a little while longer it will be observed to pant in its breathing, and to dilate its lungs to their utmost limits, as if struggling for air, precisely as is described to have occurred with the wretched prisoners in the Black Hole of Calcutta, and with the poet Crabbe. In a few hours more it will die convulsed, exactly as if drowned or suffocated. Precisely analogous results follow the deprivation of air in man, fishes, and all other animated beings; and in hanging, death ensues, not from dislocation of the neck, as is often supposed, but simply from the want of air in the lungs to effect the necessary changes in the constitution of the venous blood.

Assuming the accuracy of the estimate by Dr Southwood Smith, that in a person of average size, one pint of pure air, containing about one-fifth of oxygen, suffices to oxygenate eight ounces of venous blood, it follows that whenever the quantity of air inhaled falls short of one pint, it will prove insufficient for the formation of proper vital blood, and will consequently give rise to impaired health, or, in extreme cases, to death itself. It is perfectly unimportant to the argument whether Dr Smith has hit upon the precise relation which the air holds to the blood or not, or whether the proportion varies at different times, in different circumstances, and in different constitutions. Some proportion *does* exist which is better adapted than any other for the arterialization of the venous blood; and whatever that may be, the conclusion founded on its being attended to or neglected is equally applicable, whether one or twenty pints of air be required to oxygenate any given quantity of blood. For this reason I shall adopt Dr Smith's calculation as at least a probable one, although I am quite aware that the quantity of oxygen required varies with the state of the system and the constitution of the blood.

If, then, a certain proportion of pure air be necessary to convert venous into healthy arterial blood, it is manifest that any departure from that proportion must be injurious, because it will be to that extent insufficient for the purposes of respiration, and in opposition to the express laws of the animal economy as ordained by its omniscient Creator. We have now to shew that, daily and hourly, and under every variety of circumstances, that proportion is often absent, and that much suffering and great mortality, which might be easily prevented, are thereby induced.

There are various ways in which the lungs may be deprived of the requisite supply of pure air for respiration. In the *first* place, an obstacle may prevent the passage of the air through the windpipe: this sometimes happens in quinsy and in croup, and it may also occur from foreign bodies choking up the throat, or from strangulation. In this state, no air can be admitted to the lungs, and death is the speedy result. *Secondly,* The lungs may be deprived of their due proportion of air by any cause compressing the chest externally in such a way as to prevent the proper expansion of the lungs and air-cells. This is a frequent occurrence, and, when continued, is a very common source of bad health and diseased lungs. The most prevalent mode of compression of the chest consists in the use of tight waistbands and corsets by young women, who are anxious to possess what they consider a fine figure. Compression to a hurtful extent is also met with in many trades in which a bent position is required. Shoemakers, for example, who, when at work, sit almost doubled up, suffer from compression of the chest, and can rarely take a full breath. But in all such cases the principle is the same. The lungs are deprived of sufficient air to oxygenate the blood; and, as a consequence, the blood is deteriorated in quality, and affords imperfect sustenance to the organism. This result and its explanation are so obvious that I shall not dwell upon them, but only add two or three illustrations of the extent to which young women *voluntarily* injure themselves by compression of the chest, in the vain pursuit of an object which, thus aimed at, never fails to elude their grasp.

According to the natural formation of the lungs and chest, both are narrowest at the upper part, and become broader and broader till below the sixth or seventh rib. This will be apparent on comparing fig. 13, which shews the natural form of the chest, with fig. 14, representing the shape sometimes given it by means of external pressure. These two cuts are borrowed from Mr Wilson's work on the Skin.

Fig. 13.

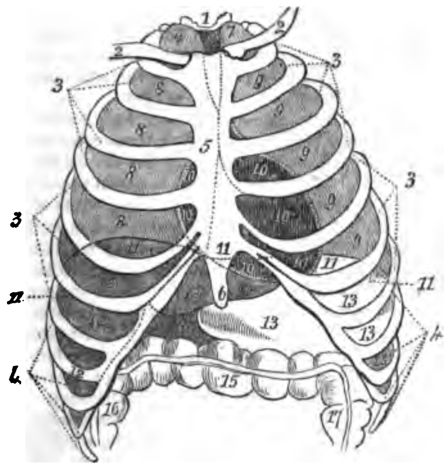

Fig. 13.—A diagram showing the natural form of the healthy chest, and the proper position of the organs which it contains.

1, The spine. 2, 2, The collar-bones. 3, 3, The seven upper, or true ribs. 4, 4, The five lower or false ribs. 5, The breastbone, with which the true ribs are joined. 6, The sword-shaped extremity of the breastbone. 7, 7, The upper part of the two lungs rising into the base of the neck. 8, 8, The right lung, seen between the ribs. 9, 9, The left lung, seen, in like manner, between the ribs. 10, 10, The heart. 11, 11, A thin layer of muscle, the midriff, which divides the upper from the lower part of the chest. Medically, that part only is the *chest* which lies above the midriff. The midriff is arched, and forms a kind of dome, upon which the heart and lungs rest. This circumstance, and the occupation of the cavity of the dome by the liver and stomach, cause the lower and front part of the lungs to lie before the upper portion of the liver; and the stomach, in like manner, to lie, in part, behind the heart. 12, 12, The liver. 13, 13, The stomach. 14, The continuation of the stomach, termed duodenum. This is the first part of the bowel, and is the frequent seat of pain. 15, The transverse portion of the large bowel or colon. 16, The upper part of the colon of the right side, bending inwards to become the transverse colon. 17, The commencement of the colon of the left side; being the continuation of the transverse colon.

Fig. 14.

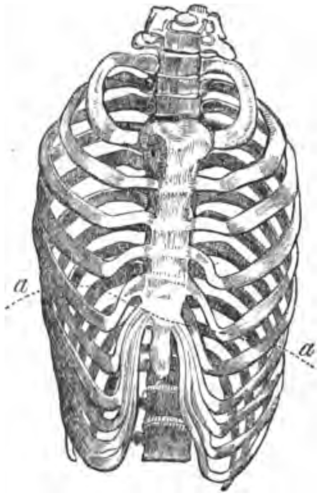

Fig. 14.—The chest distorted from the abuse of stays. If this figure be compared with the preceding, or with that on page 158, the effects of pressure will be seen at once. The figure is drawn from a chest in Mr Wilson's possession. The letters *a a* refer to a dotted line, which indicates the position of the midriff.

A similar contrast may be obtained by placing a cast of the Venus de Medicis beside any young woman who, by the diligent employment of stays, has succeeded in converting the form that the Creator bestowed on her, into one which she in her wisdom deems more beautiful. The statue of the Venus exhibits the natural shape, which is recognised by artists and persons of a cultivated taste as the most beautiful which the female figure can assume: accordingly, it is that aimed at in all the finest statues of ancient and modern times. Misled, however, by ignorance, and a false and most preposterous taste, women of fashion, and their countless flocks of imitators, down to even the lowest ranks of life, have gradually come to regard a narrow or spider-waist as an ornamant worthy of attainment at any cost or sacrifice, and endeavoured with a courage and perseverance worthy of martyrs, to reverse the proportions of nature, and produce the misshapen figure which so frequently courts admiration in our streets and ball-rooms, and which is, of course, the *beau ideal* of fashionable beauty! An inspection of the above two figures will enable the reader to judge of the extent to which, under such compression, full respiration must be impeded, or rather be rendered impossible; and how certainly the blood must be deteriorated for want of a sufficient supply of oxygen.

That such results are really experienced from compression, is proved by many facts. In the course of some experiments on the subject, Mr Thackrah found that, while the young men employed in a flax-mill could expel from the chest by a forced expiration from six to ten pints of air, the young women employed in the same mill, and consequently under similar circumstances, could expel only from two to four pints. In ten of these females, of about 18½ years of age, stated by Mr Thackrah to be "labouring under no disease," he found the average to be three and a half pints, while in the young men of the same age it amounted to six pints. Some allowance must of course be made for the naturally smaller size of the lungs in females; but Mr Thackrah seems to me to be correct in ascribing this great disparity "*chiefly* to the lacing of the chest."* I have seen one case in which the ribs were disfigured, and even the liver was deeply indented, by the pressure of a very tight waistband, and in which long-continued bad health, and ultimately death, were the results. In another case which fell under my observation, the liver was similarly indented, and its lower margin flattened by the pressure. In the Report of the Glasgow Lunatic Asylum for 1838–9, an instructive case of the same kind is mentioned. The patient was "a female pauper, aged fifty-two, who died of dropsy of the chest, connected with a singular displacement of the liver, lungs, and heart, in consequence of the very injurious practice of tight lacing, to which she had been addicted, with maniacal obstinacy, from early life." In all these cases, the lower lobes of the lungs must have been so much compressed as to render their due dilatation impossible.

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* Thackrah on Employments as affecting Health and Longevity, p. 95.

Estimating an ordinary inspiration in a healthy well-formed young woman to be twenty cubic inches of air, and supposing that, from excessive compression by corsets or a tight waistband, the expansion of the lungs be reduced so far that only fifteen inches of air can be inhaled at each inspiration, it will not be difficult to understand the deleterious influence produced by it on the general health, and on the lungs themselves. The proportion of oxygen in twenty inches of pure air is as nearly as possible one-fifth, or four inches. This, therefore, is the quantity which we assume to be required to aërate the eight ounces of blood subjected to its action. But if, in consequence of tight lacing, only fifteen inches of air can enter the lungs at each inspiration, it is as clear as noon-day that the requisite proportion of oxygen to the blood will be diminished by *one-fourth*, or reduced from *four* to *three* inches. Hence the venous blood passing through the lungs will be imperfectly arterialized, and will be relatively unfit for the support of life and nutrition. I repeat that I do not adduce these proportions as either rigidly correct or invariable, but merely as sufficient to illustrate *the principle* according to which compression acts. That its effects are really as deleterious as the application of the principle would lead us to expect, I shall presently attempt to shew by a reference to actual experience, after premising a few general observations on the nature of the changes which ensue in the blood from imperfect arterialization.

The blood, as we have seen, is a compound fluid, from which all the tissues of the body are formed, and on which all vital phenomena are directly dependent. Hence it is evident that if the blood itself be of abnormal quality, the tissues which are formed from it, and the vital stimulus imparted to the organs of the body, must be abnormal also. A morbid condition of the blood may be due either to the imperfect quantity or quality of the food presented to the organs of digestion for conversion into blood; to disease of the organs of digestion themselves; or, lastly, to an imperfect supply of the oxygen necessary for the perfect assimilation of the food, and its subsequent conversion into the products of the excretory organs. The chief cause of the maladies which flesh is heir to is expressed by this last head. When the blood is imperfectly oxygenated its vitality is lowered, and the new tissues formed from it are impaired in tone. If the imperfect oxygenation be of long continuance, the assimilation of the food becomes at last so disturbed that its product ceases to be capable of organisation, and is deposited in the tissues as scrofulous or tuberculous matter, which is regarded by pathologists as imperfectly formed fibrin. The place in which the deposit of the tuberculous matter principally takes place is the pulmonary tissue; and to such extent is this deposit occasionally carried, that more than three-fourths of the substance of the lungs may thus become impervious to air. In general, the presence of tubercles produces irritation and inflammation of the pulmonary tissue, accompanied by cough, expectoration, and the other symptoms of consumption; but it frequently happens, especially in individuals where the nutritive process is deeply depraved, that a large deposit takes place without the attention of the patient having been particularly directed to the state of the lungs, and where a shortness of breath and a loss of flesh were the only apparent symptoms. In such cases the disease, after a period of deceptive incubation, suddenly makes its appearance, and runs a rapid course, receiving on this account the name of "galloping consumption." The reader will now understand that scrofula and consumption, which are closely allied diseases, are the mere external outbreaks of a morbid condition of the system, and that scrofulous and tuberculous matter are, in the first place, the *effects*, and not the *causes*, of diseased action. It does not necessarily follow that scrofulous and tuberculous matter, when thus formed in the blood, must be deposited in the tissues of some one, or of several, of the organs of the body. The risk of this deposit is certainly great, but at the same time there are good grounds for believing that these morbid products may be thrown directly out of the system, through the capillaries of the various mucous membranes, and also through those of the kidneys.*

But when, from any cause, the balance of the circulation is disturbed, the danger of particular organs becoming implicated is greatly increased. It is a law of pathology, that whenever an organ is inflamed, an increased flow of blood takes place towards it, generally followed by an exudation of the serous and fibrinous parts of the blood. Every one knows how an inflamed finger swells, partly from an increased flow of blood, and partly from the effusion of serum and fibrin into its tissues. In like manner, an inflamed lung receives increased quantities of blood, and serum and fibrin are effused into its substance. By encroaching upon the air-cells, they render the lung more dense, and thus incapable of receiving the normal quantity of air. Where there has been previous good health, absorption of the effused substances follows on the use of appropriate remedies, and the lung regains its former condition; but where the inflammation takes place in a system with lowered tone, the effused fibrin is imperfectly organised, and is of difficult absorption. Its presence keeps up the irritation in the lungs, prepares the way for the deposition of tuberculous matter, and consumption then ensues. Hence the great risk of a "neglected cold" in individuals of low tone, or, as it is said, with "consumptive tendency." The cause of the "seat of election" of the tuberculous deposit being in the lungs, probably depends on the great vascularity of these organs (the whole amount of the blood of the body passing through them in less than two minutes), and probably also, as Dr Williams thinks, on the circumstance that the yielding nature of their texture readily admits effusion. Or it may be, that the tuberculous matter circulating with the blood meets with a certain degree of obstruction in the capillaries of the lungs, sufficient to make these organs the preferential seat of the deposit;* or finally, it has been suggested, there may be a particular attraction between the pulmonary tissue and the tuberculous matter, "expressive of a tendency in the system to free itself from the poison, by the channel which those tissues or organs afford." †

From what has just been said, then, it will be abundantly evident that *consumption is not a mere local disease*, but a symptom of *a depraved state of the constitution*, the result of imperfect assimilation of the food, or, in other words, of impaired nutrition. Hence the difficulty of its cure. The tuberculous matter may be removed by expectoration, or it may be enclosed in a cyst or bag, and thus prevented from irritating the tissue of the lungs; but unless the curative treatment be directed *to modify and improve the constitution*, and it succeed in imparting increased vitality to the blood, fresh quantities of tuberculous matter will continue to be deposited, and the strength of the patient will ultimately be exhausted. Hence it becomes a matter of the utmost importance to modify, if possible, the constitution before an actual deposit of tubercles takes place; for their presence, as we have seen, diminishes the quantity of inhaled air, and thus directly tends still further to lower the tone of the system.

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* See Brit. and For. Med.-Chir. Review, vol. iv., p. 124.

* See Brit. and For. Med.-Chir. Review, vol. iv., p. 141.

† Ibid., p. 229.

Imperfectly oxygenated blood, besides being incapable of duly nourishing the tissues, cannot afford a due stimulus to the nervous system, and this is one of the causes of languor and debility which precede the outbreak of consumption. This feeling, again, indisposes to exercise, and the withdrawal of the fresh air predisposes still further to the malady. It is at this period, accordingly, that a sea-voyage is likely to prove most beneficial, when fresh air can be inhaled without exertion, and the body be kept in a state of constant gentle exercise, without any effort on the part of the patient.

We have already seen from Mr Farr's Appendix to the Registrar-General's Second Report, that in 1838, 27½ per cent., or 90,823 deaths, arose from diseases of the respiratory organs; and that of this number no less than 59,025 were ascribed to consumption alone. Considering the numerous active causes of disease to which males are subjected, and the comparative freedom from restraint which they enjoy at the most dangerous period of life, viz., during the effervescence of youth, one should expect to meet with a large majority of the victims among them rather than among females, who are so much less exposed. In reality, however, it is otherwise. According to Mr Farr's calculations from the returns for 1838, 3·8 in 1000 males died of consumption, whereas in females the proportion was 4·1 in 1000, the actual numbers having been 27,935 to 31,090. "This higher mortality of English women by consumption," says Mr Farr, "may be ascribed partly to the in-door life they lead, and partly *to the compression, preventing the expansion of the chest, by costume. In both ways they are deprived of free draughts of vital air, and the altered blood deposits tuberculous matter with a fatal and unnatural facility. Thirty-one thousand and ninety* English women died in one year of the incurable malady! Will not this impressive fact induce persons of rank and influence to set their countrywomen right in the article of dress, and lead them to abandon a practice which *disfigures the body, strangles the chest*, produces nervous and other disorders, and has an unquestionable tendency to implant an incurable hectic malady in the frame?" *

In the First Report of the Hospital for Consumption in London, it is stated that of 888 in and out patients, 542 were males, and 346 females. This, however, affords no criterion of the relative frequency of the disease among the two sexes; for females have, in general, a greater repugnance to enter or apply at a public hospital than males, and the returns of the Registrar-General, even when allowance is made for the excess of female population, shew for the whole of England a decidedly greater mortality from consumption among females than males. In 1841 the proportion, exclusive of the metropolis, was 24,329 males to 27,937 females.† The Parisian returns, which, however, partly exclude the hospitals, give for the ten years, 1829-1838, the proportion of 8074 males against 10,840 females.‡

When to a diminished capacity of the lungs, caused by external compression, the breathing of an already vitiated air is added, the quantity of oxygen inhaled is still farther reduced, the blood is still more imperfectly aërated, and, as a necessary consequence, the health still more rapidly deteriorated. This combination of evils is nowhere seen in greater intensity than among the dressmakers of the metropolis. Deprived of that free exercise in the open air which is essential to the full expansion of the chest, they are confined in the vitiated air of a crowded workroom often for fourteen or sixteen hours a-day, and at some seasons even longer. From the tightness of their dress, and the stooping and motionless attitude in which they sit, the play of the lungs is still farther impeded. In many other trades, the same fatal combination exists; and its effects are aggravated in proportion to the impurity of the air respired.

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* Registrar-General's Second Annual Report, 8vo ed., p. 73.

† Fifth Annual Report, p. 64.

‡ Annales d'Hygiène, April 1851.

The *third* form in which the lungs are most generally deprived of the proportion of oxygen required to aërate the quantity of blood passing through them, is that of *breathing an impure or vitiated air.* If, from any external cause (such as the crowding together of many people, the burning of many lamps, or the want of ventilation), the air be rendered so impure that the twenty inches required for each inspiration contain only *three* instead of *four* cubic inches of oxygen, and if the place of the absent quantity be supplied by one cubic inch of carbonic acid, it is obvious that the blood subjected to its action will be even more imperfectly oxygenated than if only fifteen cubic inches of *pure* air were admitted to the lungs. The presence of the additional inch of carbonic acid will add to the evil arising from the want of the oxygen, by acting to that extent as a direct poison; and hence the bad health and ultimately fatal results which, as shewn in the preceding page, have so often been produced by the continued breathing of a vitiated air, especially when the vitiation is considerable in degree. And yet how very much is this important truth practically held in contempt, not only in the want of ventilation of our churches, hospitals, theatres, ball-rooms, and halls for public assemblies, but even in our private dwellings! Scarcely a day passes in which a well-employed medical man does not meet with some instance in which health has suffered, or recovery been retarded, by the thoughtless or ignorant disregard of the necessity of pure air to the well-being of the animal economy. This must be my apology for insisting at so much length, on what may seem to many a trite and exhausted topic.

Begging the reader to bear in mind the evidence already submitted of the deadly influence of *extremely* vitiated air, as experienced in the Black Hole of Calcutta, in the cabin of the steamer "Londonderry," and in the kennel into which Crabbe and his companions were thrust—and the examples of the injurious effects, in workrooms and factories, of air vitiated only in a less degree,—I shall now confine myself to shewing the powerful influence which the same cause often has in the production of specific forms of disease. It may be well, however, first to remind the reader that the injurious consequences produced are not due solely to a certain amount of carbonic acid replacing oxygen, but that the operation of the animal exhalations must also be taken into account. It is well known that breathing an air loaded with the exhalations of a patient suffering from small-pox or typhus fever frequently produces these diseases; but it is not sufficiently borne in mind that the air is rendered poisonous by the concentrated exhalations of a number of persons in health, and that the breathing of an atmosphere thus contaminated, is cause sufficient to produce fever or some other deadly malady. The first illustration which I shall give exhibits incontestibly the origin of *typhus fever* in the continued respiration of vitiated air, and is taken from the valuable *Lectures on Military Surgery* by Sir George Ballingall (page 28).

In the summer of 1811, a low typhus fever broke out in the fourth battalion of the Royals, then quartered in Stirling Castle. The season was the healthiest of the whole year, and the locality about the most salubrious in the country. On investigating the causes which could give rise to so much illness under circumstances apparently so favourable to health, the mystery was speedily solved. In one room, 21 feet by 18, SIXTY men had been placed; and in another of 31 feet by 21, SEVENTY-TWO men: in other words, a greater number of human beings had been crowded into one place than the air which it contained could by possibility keep in health. To prevent absolute suffocation, the windows were thrown open during the night, from which a cold air streamed in upon those nearest to them. The natural result of this crowding was typhus fever, to which inflammation of the lungs was superadded in those exposed to the cold draughts. The two diseases together proved very fatal. Had the officers who assigned quarters to these unfortunate men been acquainted, in the slightest degree, with the laws of respiration, and with the fact that one pair of lungs requires the use of fifty-seven hogsheads of pure air in twenty-four hours, they would, I believe, as soon have thought of ordering the men to be shot, as of exposing so large a proportion of them to almost certain death from an easily avoidable disease. The simple fact added by Sir George, that "*in the less crowded apartments of the same barracks, no instances of fever occurred,*" is the severest condemnation which can be recorded against them.

Dr Jackson, a distinguished medical officer quoted by Sir George Ballingall, gives precisely similar testimony. When insisting on "height of roof as a property of great importance in a house appropriated to the reception of the sick of armies," he adds as the reason, that "the air being contaminated by the breathing of a crowd of people in a confined space, disease is originated, and mortality is multiplied to an extraordinary extent. It was often proved in the history of the late war, that *more human life was destroyed by accumulating sick men in low and ill-ventilated apartments, than by leaving them exposed in severe and inclement weather at the side of a hedge or common dike.*" The dreadful mortality from typhus fever of the British Legion in Spain a few years ago affords another striking confirmation of the same principle.

It would be very easy to detail additional proofs of the influence of confined and vitiated air in the production of typhus fever, because they abound in the writings of every author who has treated of the subject, in the Parliamentary Reports "on the Health of Towns," and in the Registrar-General's Reports. But as the fact is almost universally admitted, I need only refer to the death from "putrid fever" of most of the survivors of the Black Hole of Calcutta; to the fearful mortality from fever in slave and emigrant ships, more from vitiated air than from any other single cause; and to the following example both of the extent to which atmospheric impurity operates, and of the facility with which its deadly influence may be obviated by due attention to the simplest laws of the animal economy.

In *Chambers's Edinburgh Journal* for 17th April 1841, in reference to the possibility of removing the causes of fever, it is said: "The chief causes assigned by medical inquirers are dense population, bad ventilation, and destitution. We shall here adduce strong reasons, to shew that however destitution or any other cause may operate remotely, the *immediate* cause is deficient ventilation. There is, in the suburb of Anderston (at Glasgow), a large house, called, from its mode of construction, and the vast crowd of human beings who live in it, the *Barrack*. It is said that nearly five hundred persons, chiefly poor Irish, live in this building, each family having one, or at most two little rooms. At one time, fever was never absent from the Barrack; *five have been seen ill at once in one room, and in the last two months of* 1831 *the cases in this single house were fifty-seven.* During the five years ending with 1839, there were 55,949 cases of fever in the whole city: consequently, it will be observed, this house with (say) 480 inhabitants, ought to have had, as its fair proportion, 112 cases, the population of the city being considered as, at a medium, 240,000. But how does the case really stand? Early in 1832, at the recommendation of an ingenious surgeon of the district (Mr Fleming), a simple tin-tube, about two inches in diameter, had been led from the ceiling of each room of the Barrack into a general tube, the extremity of which was inserted into the chimney of a furnace connected with a neighbouring factory; by which means a perpetual draft was established upon the atmospheric contents of every room, and its inmates compelled, whether they would or not, to breathe pure air. The consequence—for we cannot but consider it as the consequence—was, that during the ensuing eight years fever was scarcely known in that house. Laying aside one year, during which Mr Fleming had not the charge of the apparatus, there were up to last December *only four cases*." This remarkable exemption from fever in a building where it was formerly so prevalent is the more instructive, because the purification of the air is the only change which has been effected; and as fever was very prevalent in the whole city during the very time of this exemption, it is impossible not to ascribe the chief part of the protective power to the purer atmosphere supplied to the inmates of the Barrack.

Since the publication of the last edition of this work, I have learned that fever has again appeared in the Barrack, though its ravages, I believe, by no means equal those which it committed before ventilation was introduced. In all probability its reappearance is connected with derangement of the ventilating apparatus, but we are without information on this head.

In the First Report of the Metropolitan Sanitary Commission (p. 22), the following enquiry is made of Mr Bowie, with reference to the state of health of the inhabitants of the Model lodging-house in Glass-house Yard: "What has been the result of ventilation, as practised in the lodging-house?"—"The absence of unpleasant smells, the possession of an agreeable temperature, and an almost total exemption from febrile disease." "What is the state of health, as compared with that of the adjacent population?" "While fever has been prevailing to a very great extent in Glass-house Street, and its adjacent courts and alleys, and the verdict of a coroner's jury has been given that disease and death have been the consequence of breathing impure air, there is not at present an individual under medical treatment in the building, nor has there been a single case of fever there for upwards of four months." The Commissioners give it as their opinion (p. 10), that "in the present state of most towns and cities, the number of persons whose constitution is enfeebled by want of food, compared with the number whose vital energy is depressed by want of pure air, is found to be an exceedingly small minority."

Never before, perhaps, was this truth exemplified upon so large a scale as in the history of the late Irish famine. A deficient supply or improper quality of food, by weakening the body and lowering its tone, undoubtedly renders it liable to yield more readily to the action of deleterious influences; but it may well be doubted whether mere starvation, when associated with an abundant supply of fresh air, is ever the cause of typhus fever. In Chossat's experiments all the organs of the body, with scarcely an exception, were found remarkably healthy in animals that had died from starvation; the principal, if not only change, being a considerable reduction of weight. In like manner the Irish population remained comparatively healthy, though suffering from a deficiency of food, till they were crowded together in the wards of the union-houses. Then it was that "the angel of death spread his wings on the blast," and admission into a workhouse came to be regarded as equivalent to proscription. On 4th April 1846, the population of the Irish Union Workhouses was 50,861, and on 3d April 1847 it was 106,888; while the corresponding mortality for the two weeks ending 4th April 1846, and 3d April 1847, was 159 and 2706. Thus, with a population not much more than doubled, the weekly mortality had risen from three in every 1000 inmates, to 25 per 1000; that is to say, the *weekly* mortality became equivalent to the *annual* mortality of a moderately healthy population. No wonder, then, that the poor famine-stricken creatures should have striven to avoid their fate, "that hoping against hope, struggling against the pressure of hunger for months, knowing food might be obtained at the workhouse, but looking at its terms as their last compromise with death, they held on their cabins and their little holdings till forced forth by eviction; or their last resources having failed, and threatening fever, existing diarrhœa, having told them it must now be the union-house, or the union-coffin—then, and not till then, they closed with the terms of the law."*

It is indeed lamentable to think how many valuable lives are yearly sacrificed in every rank of society, but especially among the industrious classes, to the neglect of the well known laws of ventilation; for no fact in pathology is more firmly established than that disease and death invariably follow on overcrowding. Thus, the late Mr Pearson uniformly observed that fever prevailed in the hospitals in London to which he was attached, when more than a certain number of patients were placed in any of the wards; while, when the number of beds in each ward was limited, there was a complete absence of fever from the place.†

In his voyage to America in April 1847,‡ the author of this work was forcibly struck with the evils to which the poorer class of emigrants is exposed on shipboard from deficient accommodation, overcrowding, and under-feeding. He felt called upon to do what he could to direct public attention to the subject, and accordingly addressed to the editor of the *Times* a letter which appeared in that paper on the 17th Sept. 1847, urging upon Government the necessity of bringing into Parliament a bill for the protection of emigrants.§

That it was high time to move in the matter will be abundantly evident from the following extract from the Report of the Montreal Board of Health of 12th August 1847: "The Larch reported this morning from Sligo, sailed with 440 passengers, of whom 108 died on the passage, and 150 were sick. The Virginius sailed with 496; 158 died on the passage, 186 were sick, and the remainder landed feeble and tottering—the captain, mates, and crew were all sick." From the official returns of the burials at Montreal, for the nine weeks ending August 7th, it appears that there died during that period 924 residents and 806 emigrants in the city, beside 1510 emigrants in the sheds erected for their reception; making a total of 3240 deaths in Montreal and its extempore Lazaretto, against only 488 deaths during the corresponding weeks of the preceding year. As a comment on this fearful state of matters, we may state that Germans were arriving at the same time from the ports of Hamburgh and Bremen "all healthy, robust, and cheerful."

But, indeed, experience shews that passengers may be carried from British ports even to the distant settlements of Australia, with no increase on the natural rate of mortality, provided due attention be paid to the laws of health. In the early years of convict-transportation it was the practice of Government to pay for all who embarked, and under this system the average mortality of the convicts during the voyage was nearly one in ten, rising in particular ships, and under particularly adverse circumstances, occasionally to one in three. In later years, however, the practice of paying only for those landed alive was adopted, and the mortality immediately fell to one in 46!*

By such facts as these the attention of the Legislature has at last been roused, and an "Act for regulating the carriage of passengers in merchant vessels," was passed in the session of 1849, containing provisions which it is hoped will prevent a repetition of such fearful mortality as is above exemplified; and in 1850 the protection of the Legislature was extended to the crews of the mercantile navy, a measure which the following details will shew was most urgently needed. The researches of the Board of Health have proved that the proportion of deaths from zymotic diseases (fever, &c.) among the merchant sailors, especially when at sea, very much exceeds that among the industrious classes on shore, "indicating the presence and the steady operation of local causes of preventible disease, the extent and intensity of which have hitherto been unknown and unsuspected."* What these causes are will be seen from the following report by Mr Bowie, which is fully corroborated by the evidence of Mr Grainger, Dr Duncan, and Dr Sutherland. "After a long acquaintance," he says, "with the shipping of the port of London, and a special examination of a great number of vessels of all classes in the Thames which I have recently made in order to ascertain their condition as to cleanliness and ventilation, and particularly with a view to note the accommodation provided for the sailors, and the probable effect of the atmosphere upon their health, I find that the instances are extremely rare in which there is any special provision whatever for ventilating either the berths of the men or the hold for the cargo. These berths are for the most part dirty, close, and unwholesome; in numerous instances they are so to an extreme degree; and I am of opinion that the houses and rooms in the close courts of Whitechapel, which I habitually visit, do not as a rule exceed in the unhealthiness of their condition the forecastle of ships, in which the filth is often as great, the air as close, stifling, and offensive, and altogether as likely to generate fever, and to cause it to spread if it does break out."†

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* Letter of an eye-witness in the *Times*, June 21, 1849.

† Graves' Clinical Lectures, vol. i., p. 94.

‡ See p. 11.

§ The Letter referred to was reprinted in the Journal of Public Health, No. V., March, 1848.

* Report on Quarantine by the General Board of Health, p. 116.

The remedy for these evils is so simple and effectual, that the neglect of shipowners to adopt it becomes most culpable and even criminal. It consists simply in "inserting in the fore-part of the vessel iron-tubes communicating with the between-decks occupied by the passengers (and crew); two tubes forward to receive fresh air, and two after to discharge the foul air, so that a current of air is constantly passing between decks."* So effectually has this system of ventilation answered its purpose, that vessels of the largest class, carrying 400 or 500 passengers each, have escaped ship-fever; while its importance has been demonstrated by the fact, "*that the effluvium from the discharging tubes is so bad that it is very unpleasant to stand near them.*"† By a law of the American Congress it is required that all emigrant ships shall be provided with ventilators, and the British Legislature by the act of 1849 rendered their adoption compulsory on vessels carrying at least 100 passengers. More recently, in the session of 1850, an act "for improving the condition of masters, mates, and seamen, and maintaining discipline in the merchant-service," received the royal assent; by which it is enacted that the part of the ship occupied by seamen and apprentices shall have a space of not less than nine superficial feet for every adult, and be well ventilated. "To all natural evil," says Dr Rush, "the Author of nature has kindly prepared an antidote. Pestilential fevers furnish no exception to this remark. The means of preventing them are as much under the power of human reason and industry as the means of preventing the evils of lightning and common fire. I am so satisfied of the truth of this opinion, that I look for the time when our courts of law shall punish cities and villages for permitting any of the sources of malignant fevers to exist within their jurisdiction."

Let us hope that the measures enforced by the Acts above referred to, will in future prevent shipowners from incurring the moral culpability, under which so many of their number have hitherto laboured, for neglect of the health and lives of their servants; and that it may not be found necessary to call in the aid of the principle of *legal* responsibility which now attaches to neglect, as an additional motive to discharge their duties. "The law," say the Commissioners for the Consolidation of the Criminal Law, "takes no cognizance of homicide, *unless death result from bodily injury, occasioned by some act* or '*UNLAWFUL OMISSION.*' The terms '*unlawful omission,*' comprehend every case where any one being under legal obligation to apply food, clothing, or other aid or support, *or to do any other act, or make any other provisions for the sustentation of life, or prevention of injury to life, is guilty of any breach of such duty.*"

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* Med. Gazette, vol. xlv., p. 95.
† Report on Quarantine, p. 99.

* Report on Quarantine, p. 106.
† Ibid., p. 107.

"It is doubtless," says Mr Grainger, "a painful thing to make out, with the demonstrative evidence of statistical returns, all the elementary parts which go to form the common track of sickness, suffering, and death; and yet, as the great desideratum in sanitary as in all other investigations is the attainment of certainty, it is a point of infinite promise for the future, to demonstrate that, whatever may be the aspect of the epidemic which is traced to its home, typhus, scarlatina, small-pox, or cholera, we find but one class of causes, or to typify the whole in a single word, but one cause, and that filth, standing in the relation of the prolific parent of this diversified offspring, as it presents itself in the courts and alleys of London. It is not a question of food, for people worse fed than thousands who have become the victims of these diseases, provided they breathe day and night the fresh and bracing atmosphere of the country, escape; whilst instances are not wanting of persons amply provided with every physical comfort, lacking only pure air, falling under epidemic attacks.

"A remarkable example of the latter kind was afforded by an institution in which young women were received for the purpose of reformation, and where so destructive an attack of cholera occurred, that out of 96 inmates 40 were seized with cholera, of whom no fewer than 15, or 15 per cent., died. On inquiry into the causes of this violent attack, it appeared that there was nothing in the state of the neighbourhood, although this was in many points most defective, which could alone account for it. Nor could the general mode of living be assumed as the cause, since the diet was ample, good meat being provided six days out of the seven: in short, after a careful investigation, the only reasonable cause that could be assigned was an impure atmosphere caused by the want of ventilation in the dormitories, in several of which the windows had been partly closed up, and which were, moreover, over-crowded."*

The general result of disease following on over-crowding of the population is shewn on a large scale by the statistical returns of the Registrar-General; but we can afford room for only one "Table, shewing the mean mortality in three groups of the Metropolitan Districts," extracted from the valuable Appendix by Mr Farr, and designed to shew that, *cæteris paribus*, the mortality increases with the density of the population and the impurity of the air.

DISTRICTS.	Square Yards to one Person.	Annual rate of mortality per 1000.	The epidemic class.	Typhus.	The Nervous System.	Phthisis.	Other classes.
1 to 10 (mean)	35	3·428	·994	·349	·518	·485	·831
11 to 20 ..	119	2·786	·679	·181	·440	·405	·716
21 to 30 ..	180	2·289	·539	·131	·374	·375	·584

From this table, it appears that ·349 deaths from typhus occur in the most crowded districts of the metropolis, and only ·131 in the more favourably situated; the proportion being nearly as *five* to *two*.

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* Appendix B. to the Report of the Board of Health on the Cholera of 1848–49, p. 37.

The influence of vitiated air in the production of *consumption* has been noticed and commented upon by many observers; but the evidence of Dr Lombard of Geneva is the most conclusive, because founded on an accurate inquiry into individual cases, in the course of which he extended his researches into "a total of 4300 deaths from phthisis, and 54,572 individuals exercising 220 different occupations, and found, by a comparison of all the professions carried on in the open air and in work-shops, that the proportion of deaths from phthisis was *double* among the latter, and this proportion increased as the apartments were close, narrow, and imperfectly ventilated."* I need not add one word in support of this most convincing testimony, but only refer to another form of disease closely allied to consumption, and itself the cause of an immense mortality, viz. *scrofula.*

The three grand sources of scrofulous disease in those not strongly predisposed to it, are now universally admitted to be *the habitual breathing of a vitiated atmosphere*, an *impoverished diet*, and *impaired nutrition.* Of the active influence of the first, the rapid production of scrofula in animals previously healthy, by confining them for a time to the inspiration of an impure air, affords demonstrative proof. But, unfortunately, the fact may be witnessed at any time in the more confined dwellings of the poor in most of our large towns, and also in ill-situated and ill-ventilated workhouses or asylums for the young. Among the children in the Dublin House of Industry, for instance, scrofula prevailed very extensively about forty years ago, and its ravages were not arrested till the late Mr Carmichael, a distinguished surgeon of that city, called attention to its chief cause in the extreme impurity of the air in the wards. In one ward of moderate height, 60 feet by 18, Mr Carmichael found *thirty-eight* beds, each containing *three* children, or more than one hundred in all! The matron told him, that "there is no enduring the air of this apartment when the doors are first thrown open in the morning; and that it is in vain to raise any of the windows, as those children who happen to be inconvenienced by the cold, close them as soon as they have an opportunity. The air they breathe in the day is little better: many are confined to the apartments they sleep in, or crowded to the number of several hundreds in the school-room."* Can any one read this account, and wonder at the prevalence of scrofula under such circumstances!

We have already seen how clearly it is possible to trace the ravages of that fearful epidemic, which twice within the last twenty years has swept over the British Islands like the destroying angel, to the effects of over-crowding and deficient ventilation—causes which it is evident act by lowering the tone of the system, and rendering the body less able to withstand the choleraic influence, whatever that may be. Similar depressing causes, such as deficient food, and an impure external atmosphere arising from imperfect drainage, naturally tend to produce the same result, and the ravages of the disease have accordingly been found greatest where a combination of unfavourable circumstances existed. Such seems to have occurred in the Tooting Infant Asylum, where 300 children out of 1100 were attacked with cholera; although we find Mr Grainger, in his evidence on the trial of Mr Drouet, assigning the outbreak almost entirely to the want of ventilation. "If there had been more ventilation, I do not think there were too many beds in the room, but the want of ventilation made the over-crowding dangerous to the health of the boys. *In my opinion, the cause of the mischief was the over-crowding of the children, and that this had occasioned the disease.*" †

From a consideration of the foregoing details, then, we are forced to the conclusion that epidemics are not mere caprices of nature, but are dependent on causes which it is in our power to remove. What that subtle influence is which at one time determines the accumulated causes of disease to break out as cholera, at another as typhus fever, and at another as malignant scarlatina, we cannot tell, nor is our ignorance on this point of any practical importance; enough has been learned when we know that it is only by neglect of the general laws of health that the epidemic is enabled to acquire "a local habitation and a name." It comes as a messenger to warn us of our misdeeds; and the admirable Reports by the Board of Health which we have so frequently quoted, shew moreover that the warning is given at first gently though earnestly, and that it is only when we refuse to hearken to it that we are left to reap the natural fruits of our neglect. During the late cholera epidemic, the Sheffield Board of Guardians set earnestly to work to free their town from nuisances in anticipation of an outbreak. "They took the documents published by the General Board of Health as their guide, and proceeded with the determination of doing all that could be done, and at whatever cost, to save the town from the danger which impended over it. Unlike other Boards of Guardians, they had used the most available means for preparation, and they had nothing to seek when the emergency arrived." The result is thus stated:—" From the period when the first outbreak of cholera took place in the town to the final disappearance of the epidemic, there were brought under treatment 5319 cases of diarrhœa, and 76 cases of cholera. * * * * * 'No person' (says Dr Sutherland), 'who looks at the nature of these causes, can doubt, that they would have exhibited a much greater proportion of cholera attacks, had the preparatory symptoms not been taken. The population was enabled to resist the epidemic influence, and the small number of cholera cases, when compared with the large number of those of diarrhœa, is a sufficient proof that the object of the sanitary measures was to a great extent fulfilled.'"* There can be no doubt, that had every body having authority in the matter, set itself as zealously and honourably as the Sheffield Guardians to prepare for the coming storm, it would have passed over the country comparatively harmless. Dr Sutherland remarks, that "one of the special objects of epidemics seems that of arousing mankind, by signs which cannot be mistaken, to a sense of the necessity of recognizing and obeying the laws of his physical existence."†

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* Penny Cyclop. Phthisis.

* Carmichael's Essay on the Nature of Scrofula. Dublin, 1810.

† Med. Gazette, vol. xlv., p. 699.

The *fourth* cause by which the necessary supply of oxygen to the lungs is frequently impeded, and disease consequently produced, arises out of the sedentary habits of modern society, and the depression or monotony of mental condition which is apt to result from them. If ever a Divine law was legibly imprinted on any part of animated nature, it is that which declares ACTIVITY to be the indispensable condition of human health and happiness. Every organ, from the highest to the lowest, in the structure of man, is framed with a view to daily and habitual exercise, and this law holds equally with the lungs as with the muscles or brain. When an animal dies from starvation, it is found that the organs of digestion lose much more of their weight, before death ensues, than do the lungs or kidneys; and Chossat explains this difference by the fact of the former organs being left unexercised, while the functions of the lungs and kidneys are carried on till the close of life.‡ This is in exact harmony with the law, already pointed out, of exercise stimulating nutrition; and accordingly, when we obey this condition of existence, and actively employ the body for some hours every day in the open air, the circulation is invigorated and equalized, the respiration is rendered free and deep, and a feeling of vivacity and enjoyment arises, which is the sure accompaniment of health and energy. These results are rendered very obvious in the process of *training*, during which *the wind*, as it is called, is known to become remarkably improved. Of this I once saw a curious instance in a strong-built little Irishman, who, for a mere trifle, ran alongside of one of the Glasgow coaches for 32 miles in a very wet day and on a muddy road. The average speed was nine miles an hour, and yet the poor fellow did not seem at all distressed, and stopped only because he had arrived at his destination. In him this amazing strength and activity were obviously connected with the very complete oxygenation of the blood in a pair of capacious and well-exercised lungs.

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* Report on Cholera of 1848–49, by General Board of Health, p. 107.

† Ibid., Appendix A., p. 5.

‡ Chossat, p. 89.

The well-known salubrious influence of a gay and exhilarating mental stimulus and of cheerful and gratified moral emotions, and the sickening and destructive influence of despondency, grief, and other depressing passions, depend partly on the operation of the same principle. The exciting emotions stimulate the circulation, quicken respiration, and increase the vital powers, so that it becomes difficult to remain passive or quiescent. The depressing emotions, on the other hand, diminish the force of the circulation, render the breathing slow and feeble, and thereby withdraw the natural stimulus of life to an extent which leads directly to meditation or brooding *inaction*, and produces a positive aversion to bodily activity. Great depression of mind thus leads naturally to imperfect respiration, a more sluggish flow of blood, and the various diseases of diminished vitality; while great excitement induces full respiration, quickened circulation, and the various diseases of exalted vitality. It is, then, by diminishing inspiration, and thus depriving the lungs of the necessary oxygen, that the depressing passions and sedentary mode of life act so injuriously in predisposing to pulmonary consumption, —a fact which has been remarked from a very early period, and which ought never to be lost sight of by parents, teachers, or the young themselves. In modern society, thousands of both sexes unconsciously suffer in this way, without a suspicion being entertained that their mode of life is injurious. In female seminaries, especially, this error prevails to a lamentable extent, and is aggravated by the restraints so generally imposed upon the natural outpourings of the juvenile voice in sports and play.

Lastly, the *fifth* way in which the oxygenating functions of the lungs may be impeded is, by the mixture of mechanical impurities with the respired air. In flax-mills and other factories the vitiation of the atmosphere from this cause is carried to an extreme, and is owing to the dust and small shreds of vegetable fibre which rise from the flax and cotton in the process of manufacture. The amount of impurities which may thus vitiate the air will be evident to any one who looks at a sunbeam in a room when a carpet is being swept. Chiefly from this mechanical cause of disease, scarcely any of the work-people in some factories are free from disease; and in the heckling department of the flax-mills, according to Thackrah, a large proportion of the men die young. The same author mentions that, when conducting his experiments to ascertain the state of the lungs in the work-people employed in the flax-mills of Leeds, "the coughs of the persons waiting to be examined were so troublesome as continually to interrupt and confuse the exploration by the stethoscope."* These, it ought to be observed, were not patients selected for examination as such, but the ordinary workers from the mill.

From the explanation given above (p. 184) the reader will perceive that mechanical irritation of the pulmonary mucous membrane is exceedingly apt to produce consumption in individuals of feeble or depraved constitution. This is the cause of the frequent occurrence of the disease among the workmen in factories; among the needle-pointers and knife-grinders of Sheffield, who inhale the small particles of sand and steel which fly from their wheels; among the stone-dressers of Edinburgh, who breathe an atmosphere loaded with sandy particles; among bakers, millers, persons employed in feather-warehouses, and in general among individuals whose employment necessitates the breathing of an atmosphere holding dust in suspension. But experience has shewn that the fatality attending these occupations may be much diminished by securing, as far as possible, due ventilation, and the supply of a pure air. Thus, Sir James Clark, when treating of vitiated air as a cause of consumption among the steel-grinders of Sheffield, states that those who reside in the country, in the enjoyment of a more free circulation of air, live, on an average, eight years longer than those resident in the town. In both, the irritating causes and the habits of life are the same, but the rooms in which the country workmen carry on their labours are much better ventilated; and they consequently live on an average about forty years, while among their town companions the average of life extends only to between *twenty-eight* and *thirty-two* years.

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* On the Effects of Employments on Health, p. 43.

In Edinburgh, also, it has been observed that the stonecutters who work in the open air are much less liable to pulmonary affections than those who work in sheds. The steel-grinders of Sheffield have been recommended to wear a mask of magnetic wire, to arrest the passage of the particles of steel, and bakers to fasten a piece of moistened sponge or damp crape over the mouth during the operations in which they are likely to inhale flour. Both precautions have been used with benefit, but in the case of the Sheffield grinders the magnetic mask alone does not meet the evil, as the sand from the wheel is the principal cause of the irritation. Similar contrivances might be advantageously used in other occupations; but hitherto the ignorance and obstinacy of the workmen, who cannot be persuaded to prefer a little present trouble to the certainty of future disease and early death, have prevented their general adoption.*

From breathing a highly vitiated air in a constrained position, the people employed in some coal-mines where the seams are thin and the ventilation bad, are subject to a singular and fatal affection of the lungs, named *black spit.* In East Lothian it is very prevalent, and attacks the strongest as well as the feeblest of those exposed to its causes. It is accompanied by wasting, and the copious expectoration of an intensely black matter in large quantity, which may continue for months or years, but is never cured. In such situations, few of the men arrive at the age of forty years; and if they do, they have already the appearance of old age.

Dr Makellar traces this affection to the inhalation of an atmosphere loaded with unconsumed carbon, arising from the imperfect combustion of the lamp-oil used by the miners, and from the smoke of the gunpowder used in blasting the trap-dykes, which so frequently intersect the East Lothian coal-field. From these causes the atmosphere of the mine is frequently so thick that the workmen only recognise the presence of their fellows from the noise of their operations; while the deficiency of oxygen is occasionally so great that the lamps burn with difficulty. As an extreme instance of the deleterious consequences of breathing such an atmosphere, Dr Makellar mentions that a few years ago a great number of vigorous and healthy young men were employed in carrying a level through an extensive coal-field at Tranent, during which operation a considerable quantity of gunpowder was consumed. Every one of them was attacked with "black spit," and all died before attaining the age of thirty-five. It is worthy of notice, that this disease rarely attacks the men who are employed in conveying the coals to the foot of the shaft, and who thus have an opportunity of occasionally inhaling a comparatively pure air.*

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* Carl Bergmann thinks that the extensive and winding surface of moist mucous membrane in the nostrils of especially grazing animals, in conjunction with the narrow fissures left for the passage of air, forms a natural provision to prevent the inhalation of dust. See Müller's Archiv, 1850, p. 369.

The irritation produced in delicate lungs by the inhalation of an atmosphere loaded with the smoke of a large town, is evidently but a minor degree of that irritation which in the coal-miners of East Lothian passes into incurable disease; and we thus see that the endeavours now making in large manufacturing towns to ensure the consumption of the smoke of the factories, have a direct bearing upon the health of the population. To the inhabitants of such towns as Manchester, Leeds, and Glasgow, the success of these attempts is of very great importance.

The reader is now in a position to appreciate the unspeakable advantage of a supply of pure air to the lungs. But we must say a few words to guard against the possible misconstruction of what has been said in the last few pages. In pointing out how typhus, scrofula, consumption, or cholera, follows in the wake of deficient ventilation, we do not mean to assert that by living in an unventilated apartment a person can produce typhus, cholera, or consumption at will. What we maintain is, that *breathing an impure atmosphere lowers the tone of the system, and renders it liable to disease.* This is an invariable consequence; but the nature of the *particular malady* which ensues depends upon unknown causes, which have received the name of "the epidemic constitution." When an overcrowded and ill-ventilated emigrant-ship sets sail, the emigrants may all be in the enjoyment of perfect health. But before a week passes, the springs of life are sapped by the impure atmosphere of the crowded hold, and the emigrant is marked as a prey for disease. But it depends on the "epidemic constitution" what the disease shall be: it may be typhus—it may be cholera—it may be dysentery. The final result to the emigrant, however, is the same; for little does it matter when he is consigned to the deep, what shape the fell destroyer assumed. In boarding-schools or in infant-asylums, the result of the neglect of ventilation may appear as scrofula or ophthalmia—as malignant scarlet fever—or, as at Tooting and Taunton, as cholera; in the nursery it may shew itself in convulsions; in the ball-room in headaches, fainting fits, and hysteria. By day and by night the function of respiration is constantly going on, and a small amount of impurity—too small to be detected by our most delicate instruments—may thus by continued action so alter the composition of the blood as to produce disease and early death. A supply of pure air, therefore, is more important than a supply of wholesome food; the withdrawal of the former for a few minutes stops at once and for ever those changes of matter on which continuance of life depends.

Many writers have been at pains to point out the actual occurrence of the evils which sound physiology would lead us to expect, from the continued breathing of *impure* air, or from the imperfect breathing of *pure* air. But *the way in which the injury is done* has not been sufficiently explained or insisted upon; and hence the public at large remain unimpressed with the reality of the mischief such as I have endeavoured to set it before them. The bad effects, indeed, are often so gradual in their appearance, and apparently so unconnected with their true cause, that the prime source of the evil is apt to be overlooked, even when, to an informed mind, it is as obvious as the sun at noonday. But the influence of impure air or imperfect respiration is not the less positive or ultimately less subversive of health, from being slow and insidious in its progress. An individual possessing a strong constitution may indeed withstand the bad consequences of occasionally breathing an impure atmosphere, but even he will suffer for a time. He will not experience the same amount of mischief from it as the invalid; but he will be perfectly conscious of a temporary feeling of discomfort, the very purpose of which is, like pain from a burn, to impel him to shun the danger, and seek relief in a purer air. The comparative harmlessness of a single exposure is the circumstance which blinds us to the magnitude of the ultimate result, and makes us fancy ourselves safe and prudent, when every day is surely, though imperceptibly, adding to the sum of the mischief. But let any one who doubts the importance of this condition of health watch the dyspeptic, pulmonary, or nervous invalid, through a season devoted to attendance on crowded parties and public amusements, and he will find the frequency of headaches, colds, and other fits of illness, increase in exact proportion to the accumulated exposure, till, at the end of spring, a general debility has been induced, which imperatively demands a cessation from festivity, and a change of scene and air. This debility is often erroneously ascribed wholly to the unwholesome influence of spring,—a season extolled by the poets, not as a cause of relaxation and feebleness, but as the dispenser of renovated vigour to every class of living beings.

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* Investigation into the nature of Black Phthisis, by Dr A. Makellar. Edin. 1846.

It is in vain to warn such persons beforehand that Nature is always consistent, and that if bad air be really unfit for healthy respiration, it must be detrimental *to them*, and to all who breathe it; and that its ill effects are not less real because at first gradual and unperceived in their approach. They know too little of the animal economy and of Nature's laws, and are too much devoted to their own objects, to be impressed by cautions of this kind; and, in looking forward to the ball-room or crowded saloon, few of them will believe that any possible connection can exist between breathing its vitiated atmosphere, and the headaches, indigestion, and cutaneous eruptions which so frequently follow, and to be delivered from which they would sacrifice almost every other enjoyment.

If it be said that nobody will be troubled with all this trifling care, and that thousands who expose themselves in every way, nevertheless enjoy good health and a long life, I can only answer that this is partially true; but that an infinitely greater proportion pass through life as habitual invalids, and scarcely know from experience what a day of good health really is. The Reports of the Board of Health and the Registrar-General have demonstrated, by an unassailable mass of evidence, that many circumstances, rarely considered as injurious, because they have no *immediate* effect in suddenly destroying life by acute diseases, have nevertheless a marked influence in slowly undermining health and shortening human existence. There are trades, for example, at which workmen may labour for fifteen or twenty years, without having been a month confined by disease during all that time, and which are therefore said to be healthy trades; and yet, when the investigation is pursued a little further, it is found that the general health is so steadily, although imperceptibly, encroached upon, that scarcely a single workman survives his fortieth or fiftieth year.

It is this insidious influence of impure air to which I am anxious to direct attention. So long as delicacy is the rule, and robust health the exception, especially among females, and so long as about one-fourth of the annual deaths among the adult population of Great Britain is caused by consumption alone, it will be difficult to persuade any rational and instructed mind that every cause of disease is already removed, and that farther care is superfluous. My own conviction on the contrary is, that, by proper care, and a stricter observance of the laws of the animal economy on the part of the parents and guardians of the young, the development of the disease might be prevented in a large proportion of the number, and that even the robust might be enabled to enjoy health in a higher degree and with increased security.

The reader having now become acquainted with the nature and laws of *the function of respiration*, it will not be difficult for him to understand the principal conditions on which *the health of the lungs*, or organs of respiration, more immediately depends, and the means by which, when feeble or predisposed to disease, they may be best protected and invigorated. Considering the yearly mortality from consumption, this part of our subject cannot fail to excite a deep interest in the mind of every rational parent.

If, as we have shewn, the habitual breathing of a pure air be essential to the proper constitution of arterial blood, and to the general well-being of the system, there can be no doubt that the same condition will exercise a still more direct influence on the health of the lungs themselves. This is accordingly the case; and, following the order of our previous exposition, it may be stated, that the *first* great requisite for the health of the lungs is *the habitual respiration of a pure air, at a moderate degree of temperature, and of a moderate degree of humidity or dryness.*

There are only two ways by which an unlimited command of pure air can be obtained for respiration. The first is by living in the open air; and the other is by making arrangements for the frequent and regular renewal of air within our houses, workshops, churches, schools, and other places of public resort. The former is clearly impracticable in this climate; for however much we may benefit by a few hours spent every day in active exercise in the open air, no one will venture to affirm that we could safely spend the whole four-and-twenty under similar exposure. The only other way requiring consideration, is *the regular renewal of the air in our houses and places of general resort.*

Keeping in mind that every pair of lungs consumes on an average about 120 gallons of air per hour, in the oxygenation of about 57½ gallons of blood, and also the numerous other sources of the impurity of the air, such as fires, lights, and the cutaneous and pulmonary exhalations, there can be no difficulty in understanding how indispensable a regular supply of pure air must be to the health and comfort of every one who remains even for an hour within the four walls of a room, and especially if it be crowded with human beings. If we suppose, for example, that a thousand persons remain together in a church for an hour and a half, and that no provision has been made to renew its contained air, what will be the results? A thousand pairs of lungs will, in that space of time, require for healthy respiration 120,000 gallons of air to oxygenate about 57,500 gallons of venous blood. But if no provision be made for the supply and equal diffusion of pure air, and for withdrawing the air which has been vitiated, healthy respiration will become physically impossible. The vitiated air does not contain, and consequently cannot afford, the 21 per cent. of oxygen which the blood demands, and which pure air always contains. But in place of the absent oxygen, the corrupted air contains a surplus of carbonic acid, which, instead of being serviceable, directly increases the deleterious effects. According to the observations of Valentin, 1000lb. weight of adult human beings give off hourly by the lungs about ·18lb. of carbon,* which represent 1·45lb. of flesh: † that is to say—among a crowd, for every 1000lb. weight of body present, there is an hourly waste of the tissues, of nearly 1½lb.; or, for every 1000 people present, the bodies of 1½ may be supposed to have been resolved into their constituent elements, and dispersed through the atmosphere. Of course this calculation, which rests on the supposition that all the carbon given off by the lungs is derived from decomposition of the tissues, can give but a very rude idea of the amount of the chemical transformations; for it must be remembered that no inconsiderable portion of the primary elements of the tissues remains in the body, to form the urine and the alvine evacuations. It varies very much, moreover, according to the age of the individuals and the temperature of the air.

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* Flesh contains 75 per cent. of water, and of the remaining 25 per cent., only about half is composed of carbon. Thus, 1lb. of flesh contains about ·125lb. carbon. In the text, flesh is taken as the representative of the tissues.

† Lehrbuch, vol. i., p. 585.

Although, as has been already shewn, carbonic acid is not the sole deleterious principle contained in air vitiated by respiration, it is useful as a standard by which to measure the degree of vitiation which the air has undergone. We have seen that the expired air contains on an average 4 per cent. of carbonic acid; consequently, if on analysis the air of any room be found to contain this proportion of carbonic acid, it will prove that all the air present has passed through the lungs. If the proportion of carbonic acid be one-half per cent., then an eighth of the whole mass of air must have passed through the lungs; and, accordingly, as soon as the amount of carbonic acid reaches one-half per cent., every inspiration we make contains an eighth less than the normal amount of oxygen, and an eighth part of the inhaled air has already passed through our own or our neighbours' lungs. This amount of vitiation is of common occurrence, and we thus frequently see the most fastidious individuals, who would scruple to eat what had been touched by their neighbour's hand, inhale, without objection, the breath which has just issued from their neighbour's nostrils![*]

Several experiments have been made by Leblanc[†] with a view of determining the degree of vitiation which the air undergoes by the respiration of a crowded assembly. In one, 180 boys, from seven to ten years of age, were confined for four hours in a school-room containing 721 cubic mètres of air.[*] Communication with the external atmosphere was cut off; but it is almost impossible to do this so effectually as to prevent all interchange between the external and internal air.[†] During the experiment the master complained of the hot, heavy, and unpleasant atmosphere, and waited impatiently for liberation. Analysis shewed that the carbonic acid amounted to ·87 per cent., or about 20 times the normal quantity contained in the air. It was only 4½ times less than that found in the air issuing directly from the lungs, and thus shewed that at the close of the experiment every inspiration contained between a fourth and a fifth part of air that had been already breathed. In another experiment the atmosphere of the chemical amphitheatre of the Sorbonne at Paris, containing 1000 cubic mètres of air, was found, after the expiry of a lecture of an hour and a half's duration, which had been attended by 900 students, to contain 1·03 per cent. of carbonic acid, although two doors stood open during the whole time. The air, however, had been previously contaminated to the amount of ·65 per cent. of carbonic acid during a preceding lecture, so that the students had all along been breathing a corrupted atmosphere. The extent of contamination at the close of the experiment indicated that a quarter of the air of each inhalation had already been respired. We have seen that carbonic acid produces a directly depressing effect upon the system, lowering the nervous energy, and diminishing the quantity of carbonic acid thrown off by the lungs. Hence a contaminated atmosphere must always act with twofold power; the system suffering directly from the accumulation of the poison in the atmosphere, and indirectly from the lowered tone of the nervous system, consequent on the impeded excretion of the carbonic acid. Hence, again, the increased susceptibility to disease.

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[*] Shakspeare makes Cleopatra look forward with disgust to the circumstances that would attend her gracing of Cæsar's triumph:—

* * * "Mechanic slaves,
With greasy aprons, rules, and hammers, shall
Uplift us to the view; in their thick breaths,
Rank of gross diet, shall we be enclouded,
And forced to drink their vapour.
Iras. The gods forbid!"

Antony and Cleopatra, Act v., Scene 2.

[†] Annales de Chimie et de Physique, 3me Série, vol. xv.

[*] The cubic mètre contains 220 gallons, or 35 cubic feet.

[†] See Ann. de Chim. et de Phys., 3me Série, vol. xxvii., p. 382, note No. 2.

So wholly, however, have considerations of this description been without influence on the public mind, and so complete and all-pervading has been the ignorance of physiology even among the best-educated classes, that in Edinburgh, and almost every large town, we have instances of large public rooms, capable of holding from 800 to 1000 persons, built within these few years, without any means of adequate ventilation being provided, and apparently without the subject having ever cost the architect a thought! When these rooms are crowded and the meeting lasts for some hours, the consequences are sufficiently marked. Either such a multitude must be subjected to all the evils of a contaminated and unwholesome atmosphere, or they must be partially relieved by opening the windows, and allowing a continued stream of cold air to pour down upon the heated bodies of those who are near them, till the persons so exposed are thoroughly chilled, and perhaps, as in the case of the soldiers in Stirling Castle, fatal illness is induced. And unfortunately, even at such a price, the relief is only partial; for the windows being all on one side of the room, and not extending much above half-way to the ceiling, complete ventilation is impracticable. This neglect is glaringly the result of ignorance, and could never have happened had either the architects or their employers known the laws of the human constitution; and yet it is still doubted whether it be prudent or right to teach the intelligent portion of the community any knowledge of the structure and uses of their own organism! *

Striking, indeed, as these and innumerable other facts of a similar nature are, we still remain so blind to the instructions of experience, until we acquire a knowledge of the principles which give it value, that we go on, especially in towns, constructing our houses in utter defiance of scientific rules. The sitting-rooms, which can be easily ventilated at any time, —which are in fact ventilated by the constant opening and shutting of the door, and by the draught of the chimney,—and in which, therefore, large dimensions are less necessary for salubrity, are always the most spacious and airy. The bed-rooms, on the other hand, in which, from the doors being shut, and from there being no current of air in the whole seven or eight hours during which they are occupied, the vitiation of the air is the greatest, and in which, consequently, size is most required, are uniformly the smallest and most confined; and, as if this source of impurity were not sufficient, we still further reduce the already too limited space by surrounding the bed with curtains, for the express purpose of preventing ventilation, and keeping ourselves enveloped in the same heated atmosphere. Can any thing be imagined more directly at variance than this with the fundamental laws of respiration? Or could such practices ever have been resorted to, had the nature of the human constitution been regarded before they were adopted? In this respect we are more humane towards the lower animals than to ourselves; for, notwithstanding all the refinements of civilization, we have not yet aggravated the want of ventilation in the

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* I rejoice to say, that since the publication of the earlier editions of this work, the want of ventilation in the Assembly and Waterloo Rooms has been partially obviated. Their original construction scarcely admits of a complete remedy. In most instances of attempted ventilation of public rooms, ample means are afforded for the escape of vitiated air, but in consequence of the inadequacy of the arrangements for the admission of fresh air to supply its place, the outward current through the openings in the ceiling is far slower than it ought to be. Let it always be kept in mind that successful ventilation implies an easy entrance as well as egress of the air.

stable or the cow-house, by adding curtains to the individual stalls of their inmates.

In dwelling-houses lighted by gas, the frequent renewal of the air acquires increased importance. A single gas-burner will consume more oxygen, and produce more carbonic acid to deteriorate the atmosphere of a room, than six or eight candles. If, therefore, where several burners are used, no provision be made for the escape of the corrupted air, and for the introduction of pure air from without, the health will necessarily suffer. A ventilator placed over the burners like an inverted funnel, and opening into the chimney, is an efficient and easy remedy for the former evil; and a small tube forming a communication between the external air and the room, would supply fresh air, where necessary. The tube might be made to pass, like a distiller's worm, through a vessel containing hot water; by which means the air might be heated in very cold weather, before being thrown into the room, and thus the danger arising from cold draughts and inequalities of temperature be avoided.

Mr Faraday has recently invented a lamp which burns in a glass globe in such a manner that the product of the combustion is at once carried off, and not allowed to mix with the air of the room at all. Such lamps might fitly be introduced in staircases, and rooms where fixed lights are sufficient, and would thus tend materially to secure the purity of the atmosphere of the house. In Edinburgh, and most of the towns of Scotland, gas has been introduced into the houses, and is now the light in general use; but, in the absence of all means to ensure ventilation, beyond what is afforded by the chimney, there is reason to fear that its introduction has proved injurious to the health of the community. Upon delicate individuals it certainly exercises a deleterious influence, producing headaches and indigestion; but it is doubtful whether these consequences arise, simply from the vitiation of the air caused by the combustion of the gas being large in comparison with that produced by candles or lamps, or to some extent also from minute quantities of sulphuretted hydrogen remaining as impurities in the gas. The custom which obtains in jewellers' and silversmiths' shops, of burning oil in preference to gas, owing to the tarnishing of the silver which the latter more readily produces, and the fact that it is impossible to preserve the more delicate plants alive in rooms where gas is burned, give considerable support to the latter view. At all events, invalids should guard against burning large quantities of gas when there is no provision made for ventilation. We believe that this is the unsuspected source of much bad health, and have seen great benefit derived from substituting other lights for gas. We have also reason to think that much of the beneficial effects resulting from a change to the country is frequently due to the absence of gas-illumination; and, in an instance known to us, of a lady who on one occasion was disappointed of the benefit she had previously always derived from country air, no cause of the unusual result could be discovered, except that in this instance the house she had taken was lighted with gas.

Many of our churches and school-rooms are extremely ill ventilated; and accordingly it is observed that fainting and hysterics occur in churches much more frequently in the afternoon than in the forenoon, because the air is then at its maximum of vitiation. Indeed, it is impossible to look around us in a crowded church, towards the close of the service, without perceiving the effects of impure air in the expression of every one present. Either a relaxed sallow paleness of the surface, or the hectic flush of fever, is observable: and, as the necessary accompaniment, a sensation of mental and bodily lassitude is felt, which is immediately relieved by getting into the open air.

The feeling of oppression is always considerably greater in the galleries than in the body of a church, because the heated impure air ascends in consequence of its greater specific lightness. Hence, the upper strata of air in a theatre were found by M. Loppen to contain nearly twice as much carbonic acid as the lower,* and the difference in temperature between the upper and lower strata of air in a room 21 feet high, receiving fresh air from below, was found by M. Duvoir to amount to 30° F.† This last, however, is an extreme instance; for, in general, unless in crowded rooms with numerous lights, the difference ranges from 5° to 10°.

It has long been observed that typhus fever abounds in the upper stories of the high houses of the Old Town of Edinburgh, and some difficulty was experienced in accounting for its frequent occurrence in situations which, from their very altitude, might be supposed to enjoy a comparatively pure atmosphere. Dr Sutherland has solved the question by shewing that the impure air of the lower stories filters gradually through the floors, and passes to the upper stories, the atmosphere of which becomes more and more fetid the greater the number of inhabited floors below. "The middle floors are the most healthy, as being equally removed from the effects of the upward drainage of the foul and unwholesome internal atmosphere, and the offensive exhalation from the uncleansed and undrained streets below. From their greater proximity to the latter cause of disease, the ground flats rank next in unhealthiness; while the top flats, from becoming, as it were, cesspools for the aërial drainage of all the stories below, were found to be far the most liable to attacks of epidemic cholera. The result is very striking, and points to the existence of causes of epidemic disease in the Scottish cities which have hitherto attracted too little attention. They are the same in character, but far more aggravated in degree, than those which have been observed to exist in the upper flats of unventilated cottages and workshops by Mr Chadwick and other observers."*

I have seen churches frequented by upwards of a thousand people, in which, during winter, not only are no means of ventilation employed during service, but even during the interval between the forenoon and afternoon services, the windows are kept as carefully closed as if deadly contagion lay outside, watching for an opportunity to enter by the first open chink—and where, consequently, the congregation must inhale, for two hours in the afternoon, an exceedingly corrupted air, and suffer the penalty in headaches, colds, and bilious and nervous attacks. On this account the afternoon service in ill-ventilated churches should be especially avoided by delicate individuals. In one instance which came under our observation, the vitiated air invariably produced headaches and indigestion, frequently followed by severe sickness and vomiting.

Most schoolhouses also are extremely defective in this respect. It is now many years since, on the occasion of a visit to one of the classes of a great public seminary, my attention was first strongly attracted to the injury resulting to the mental and bodily functions from the inhalation of impure air. About 150 boys were assembled in one large room, where they had been already confined nearly an hour and a half when I entered. The windows were partly open; but, notwithstanding this, the change from the fresh atmosphere outside to the close contaminated air within, was exceedingly obvious, and most certainly was not without its effect on the mental faculties, accompanied as it was by a sensation of fulness in the forehead, and slight headache. The boys, with every motive to activity that an excellent system and an enthusiastic teacher could bestow, presented an aspect of weariness and listlessness which the mental stimulus they were under could not overcome, and which forcibly recalled sensations long bygone, which I had experienced to a woful extent when seated on the benches of a similarly constructed school. These observations stirred up a train of reflections; and when I called to mind the freshness and alacrity with which, when at school, our morning operations were carried on, the gradual approach to languor and yawning which took place as the day advanced, and the almost instant resuscitation of the whole energies of mind and body that ensued on our dismissal, I could not help thinking that, even after making every necessary deduction for the mental fatigue of the lessons and the inaction of body, a great deal of the comparative listlessness and indifference was owing to the continued inhalation of an air too much vitiated to be able properly to purify the blood, which was thus rendered incapable of affording to the brain the degree of stimulus on which its efficiency so essentially depends. This appeared the more probable when I recollected the pleasing excitement occasionally experienced for a few moments, from the rush of fresh air which took place when the door was opened to admit some casual visitor. Indeed, on referring to the symptoms induced by breathing carbonic acid gas, it is impossible not to perceive that the headache, languor, and debility consequent on confinement in an ill-ventilated apartment, or in air vitiated by many people, are but minor degrees of the same process of poisoning which ensues on immersion in pure carbonic acid. Of this mode of poisoning, "*great heaviness in the head, tingling in the ears, troubled sight, a great inclination to sleep, diminution of strength, and falling down,*" are stated by Orfila as the chief symptoms; and every one knows how closely these resemble what is felt in crowded halls.

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* Annuaire de Chimie, 1846, p. 787.

† Lévy's Hygiène, vol. ii., p. 579.

* Appendix (A) to the Report of the General Board of Health, on the Epidemic Cholera of 1848 and 1849.

Another instance of the noxious influence of vitiated air, which made a very strong impression on my mind, was during a three hours' service in a crowded country church, in a warm Sunday of July. The windows were all shut, and in consequence the open door was of little use in purifying the atmosphere, which was unusually contaminated, not only by the respiration and animal effluvia proceeding from so many people, but by their very abundant perspiration, excited by the heat and confinement. Few persons of the lower classes, either in town or country, extend their cleanliness beyond the washing of the hands and face. Hence the cutaneous exudation, in such persons, is characterised by a strong and nauseous smell, which, when concentrated, as it was on this occasion, becomes absolutely overpowering. Accordingly, at the conclusion of the service, there was heard one general buzz of complaint of headache, sickness, and oppression; and the reality of the suffering was amply testified by the pale and wearied appearance even of the most robust. Nor was this result at all surprising. The natural stimulus of the brain is healthy uncontaminated blood, and daily experience shews us how small a degree of impurity is necessary to produce a sensible effect upon it. Thus the inhalation of ten drops of chloroform, occupying perhaps half a minute, is sufficient, in some constitutions, to produce total insensibility; while one inspiration of the vapour of prussic acid has been known to cause instantaneous death. These substances are absorbed by the capillaries of the lungs, and carried by the current of the blood to the brain, where their injurious action is produced. In like manner the animal effluvia collected in a confined air are taken up by the blood, which is thus rendered incapable of affording a healthy stimulus to the brain. Hence the headaches and sickness which the breathing a foul atmosphere so often produces. "I have to walk the Outer-House every forenoon," says Francis Horner, "which gives me a constant headache, and debilitates me for the remainder of the day."* But the evil does not always stop here. The blood may be so contaminated that removal to a pure atmosphere fails to restore the system to its previously healthy condition. The poison takes root in the organism, and, after a period of incubation, shews itself as typhus fever or dysentery. The poison is here not so definite in its nature as that of small-pox, but it is analagous in its action. Some time after the respiration of a foul atmosphere in the one case, and after inoculation in the other, disease appears,—the consequence of the growth of the poison which has been implanted in the system, and which Nature is incapable of eradicating. Some constitutions, such as the feeble and depraved, afford a more favourable soil for the reception and growth of animal poisons than others, and hence it happens that all who are exposed to their action do not suffer alike. We can now understand why one of the circumstances which greatly aggravates the bad effects of the vitiated air in most schools, is the very long time during which the pupils are subjected to its influence. In winter, the whole day is generally spent in school, and exercise in the open air becomes impossible. In summer, six or seven successive hours of confinement are common, in addition to which even the evenings are consumed in private preparation for the *tasks* of the morrow. Considering the structure and constitution of the human being, a more irrational and more injurious system of education could scarcely be invented. The brain alone is exercised, and its exercise is carried to the degree of exhaustion; while the lungs,, the muscles, and the bones, on the exercise of which the health even of the brain directly depends, are neglected, and injured by disuse. Apathy and exhaustion are the natural effects of breathing air vitiated by the lungs of so many companions for so many successive hours. The attention flags, the mind becomes indifferent to everything except an intense longing for liberty and the open air, and the body itself becomes weary and restless.

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* Memoirs, Chambers's ed., p. 68.

Since the publication of the early editions of this volume, several intelligent teachers, who were struck with the truth of these remarks, and had the courage to act upon the dictates of a sound physiology by greatly abridging the hours of confinement, encouraging active play in the open air several times a-day, and ensuring the thorough ventilation of the school-rooms at all times, have expressed themselves delighted with the results, and declared that even the intellectual progress was greater with only one-half of the confinement, while the health, and power of sustained and vigorous attention, were greatly improved. Similar testimony was repeatedly offered to Mr Combe by teachers in the United States. "After the lecture," he says on one occasion, "the teacher of a distinguished private seminary mentioned to me, that, in consequence of the views which he had derived from my lectures on phrenology last year, he had ventilated his school, alternated the studies, and increased the hours of relaxation, and had found the health of himself and his scholars improved, their powers of application increased, and greater enjoyment imparted to them all."[*] Again, in speaking of a new and thoroughly ventilated public school at Boston, Mr Combe says: "The teachers told me that since they have occupied this school-house, the vivacity and capacity of the scholars have obviously been raised, and their own health and energy increased."[†]

Of the direct influence thus produced on the health of the children, the following facts, taken from among many others in the Honourable Horace Mann's *Second Report to the Board of Education of Massachusetts*, will be sufficient evidence. Of two school-houses situated near each other, the one was dry and *well-ventilated,* and the other damp, and so placed that *ventilation was impracticable.* "In the former," says Mr Mann, "during a period of forty-five days, *five* scholars were absent from sickness, to the amount in the whole of twenty days. In the latter, during the same period of time, and for the same cause, *nineteen* children were absent to an amount in the whole of *one hundred and forty-five* days." "The appearances of the children thus detained by sickness indicated a marked difference in their condition as to health."

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[*] Combe's Visit to the United States, vol. iii., p. 169.

[†] Ibid., p. 155.

One of the evils of ignorance is, that we often err and suffer the consequences, without being aware that we are acting amiss, and that it is in our power to escape the suffering by avoiding the error. For many generations, mankind have experienced the evil results of deficient ventilation, especially in towns, and suffered the penalty of delicate health, headaches, fevers, consumptions, and cutaneous and nervous diseases; and yet, from ignorance of the true nature and importance of the function of respiration, and of the great consumption of air in its performance, architects have gone on planning and constructing edifices, without bestowing a thought on the means of supplying them with fresh air, although animal life cannot be carried on without it;—and, while ingenuity and science have been taxed to the uttermost to secure a proper supply of water,—pure air, though far more essential, has been left to steal in like a thief in the night, through any hole by which it can find an entrance. In constructing hospitals, it is true, ventilation has been thought of, because a notion is prevalent that the *sick* require fresh air, and cannot recover without it; but it seems not to have been perceived, that what is indispensable for the recovery of the sick, may be not less advantageous in *preserving* from sickness those who are well. "Man," says Mr Waterton, "acts strangely. Although a current of fresh air is the very life of his lungs, he seems indefatigable in the exercise of his inventive powers to deprive himself of this heavenly blessing. Thus he carefully closes every cranny of his bed-chamber against its entrance, and he prefers that his lungs should receive the mixed effluvium from his cellar and his larder, and from a patent little modern aquarius, in lieu of it. Why should man be so terrified at the admission of night air into any of his apartments? It is nature's ever-flowing current, and never carries the destroying angel with it. See how soundly the delicate little wren and tender robin sleep under its full and immediate influence, and how fresh and vigorous and joyous they rise amid the surrounding dew-drops of the morning. Although exposed all night long to the air of heaven, their lungs are never out of order, and this we know by the daily repetition of their song. Look at the newly born hen, without any nest to go to. It lives and thrives, and becomes strong and playful, under the unmitigated inclemency of the falling dews of night. I have here a fine male turkey, full eight years old, and he has not passed a single night in shelter. He roosts in a cherry-tree, and always is in finest health the year throughout. These dunghill fowls, preferring this cherry-tree to the warm perches in the hen-house, took up their airy quarters with him early in October, and have never gone to any other roosting place. The cow and the horse sleep safely on the cold damp ground, and the roebuck lies down to rest in the heather, on the dewy mountain's top. I myself can sleep all night long, bareheaded, under the full moon's watery beams, without any fear of danger, and pass the day in wet shoes without catching cold. Coughs and colds are generally caught in the transition from an overheated room to a cold apartment, but there would be no danger in this movement if ventilation were properly attended to—a precaution little thought of now-a-days."* It must not be supposed, however, that we mean to advocate the practice of sleeping out of doors, or of passing the day in wet shoes; our present object is merely to shew, that in healthy well-drained districts there is no reason why night air should in itself be unhealthy. The air which penetrates into our houses must be derived from the external atmosphere, and during the night must be *night air*. The danger in sleeping out of doors does not, then, consist in inhaling night air, but in becoming chilled from insufficient clothing, or being drenched by rain. The case, however, assumes a different aspect when it is a question of sleeping out of doors in humid marshy districts. There the atmosphere is loaded with deleterious exhalations, which, being condensed by the cold of night, act injuriously on the human constitution, and from which the shelter of a house affords a certain amount of protection.

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* Waterton's Essays on Natural History.

Dr Thom tells us that "when cholera showed itself in Hydrabad, in forty-eight hours it carried off 96 out of about 400 prisoners who were confined in a very imperfectly ventilated gaol, and that almost every ship carrying coolies from Calcutta to the West Indies was attacked with cholera in the first fortnight of the voyage: these poor creatures in all probability labouring under a choleraic diathesis on shore, *by sleeping in the open air did not suffer*; but no sooner were they cooped up on board a vessel, and hundreds of them stowed down into the ''tween decks,' at night at least, or in the day-time also if the weather was bad, than they got cholera."*

Were the communication of general knowledge of the structure of man made a regular part of a liberal education, scientific architects would speedily devise the best means of supplying our houses with pure air, as the engineer has already supplied them with pure water, and we should cease to have occasion to lament the lives of hundreds thus sacrificed through ignorance and neglect. One of the simplest methods of ventilating the rooms of private houses is the introduction of a balanced metallic valve into the wall of the room, close to the ceiling, and opening a communication with the chimney. The foul air, from its greater heat and consequent lightness, rises to the opening, while the draught caused by the chimney sucks it in. This is the system of ventilation recommended by Dr Arnott, and it has been found to add very much to the salubrity of crowded apartments. In private houses, however, its use is open to some objections. If the draught up the chimney be not strong, smoke is apt to flow backwards into the room in spite of the opposing action of the valve,—while at other times the draught of air caused by it is excessive, especially during the prevalence of high winds. In ventilation it is necessary to provide for the free admission of fresh air, as well as for the escape of that which is foul; when this is not attended to, the air forces itself in at every chink, and unpleasant draughts are the consequence. Indeed it often happens that where apertures only for the escape of foul air exist, the draught caused by the chimney reverses the intended action, and a current of air rushes down through them into the room. It should therefore, as we formerly hinted, be the study of the architect, in planning every building, to provide means for the supply of pure air at a genial temperature, as well as to ensure its escape when vitiated—and to effect this by a supply so regulated as to avoid the occurrence of draughts.

The truth of the doctrines here inculcated is strongly confirmed by the experience of the highly respectable establishment in which this volume is printed. For years the workmen employed in it were exposed to the full influence of the vitiated air arising in printing-houses from the nature of the materials, the presence of many persons in the same room, and the numerous lights required, especially in winter; the whole of which together formed an atmosphere sickening and oppressive to those unaccustomed to it, but of the true nature of which, those habitually exposed to it received a much fainter impression. On the attention of the partners being drawn to the importance of pure air to bodily health and mental activity, they became anxious to effect a thorough ventilation of their premises. The plan resorted to was very simple: a hole six or eight inches square was opened into a disused chimney at each end of the principal apartments, the upper edge of it being on a level with the ceiling. The warm vitiated air naturally ascends, and, having the benefit of the draught through the chimney, is readily carried up, and a good ventilation is thus established. The consequent improvement in the comfort and working power of the men is, I understand, not less remarkable than the difference in comfort and freshness to a stranger entering from the open air. The same plan has been adopted in the printing-office of the *Scotsman* newspaper; and I have been told by one of the proprietors, that there the workmen are now as little exhausted at the end of a day including two or three hours of extra labour, as they were before by their ordinary exertion. That the caution given above, however, against the occurrence of draughts from an abundant but ill-regulated supply of fresh air at a low temperature, is not uncalled for, is proved by many examples of the bad effects which they are apt to produce. A writer in the *Lancet* (29th December 1832), after narrating a case of a patient who was carried off by pleurisy while under treatment by Dr Elliotson, in St Thomas's Hospital, for disease of the pylorus, gives his opinion, that the pleurisy "was most likely occasioned *by the extreme draughts of this ward.* There is a great current of air in the ward, and I have seen many persons in it suffer very much indeed." In a note it is added, "*The number of patients who are thus carried off yearly, forms a startling list to be laid before the eyes of the Governors of this Institution. Such results are shamefully frequent.*" I have already noticed the occurrence of pulmonic inflammation from the same causes in the garrison of Stirling Castle; and it is to be feared that there are many, both schools and hospitals, as much in need of improvement in this respect as St Thomas's is stated to have been.

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* Report of General Board of Health on the Cholera of 1848-49, p. 40.

It would serve only to encumber these pages needlessly, were I to adduce here in detail any further evidence that the purity and due renovation of the air which we breathe, is really influential in promoting the healthy and energetic activity of body and mind. The proofs already given are amply sufficient to establish the fact. But, that no doubt may exist in the mind of even the most incredulous or inattentive reader, I shall refer shortly to one or two instances, in which, by the observance of this law of the human constitution, health was extensively preserved, where, when the law was neglected, unusual sickness and mortality prevailed.

We have already seen that a free circulation of air in the sick-room is the most effectual means of preventing the spread of fever. Sir Walter Scott notices incidentally that it was equally efficacious in preventing the extension of plague to the inmates of the Old Tolbooth, or Prison, of Edinburgh, which he has rendered famous under the name of "The Heart of Mid-Lothian." "Gloomy and dismal as it was, the situation in the centre of the High Street rendered it *so particularly well-aired, that when the plague laid waste the city in* 1645, *it affected none within these melancholy precincts;*"* and yet, in other respects, a gaol was precisely the place where the plague might have been expected to prevail with the greatest virulence.

About a hundred years ago, when the pauper infants of London were brought up in the workhouses, amidst impure air, crowding, and want of proper food, out of 2800 received into them annually, the frightful proportion of 2690 died within the year! When this murderous mortality at length attracted the notice of Parliament, an act was passed obliging the parish-officers to send the infants to nurse in the country. Under this more humane treatment, the mortality speedily fell to 450, being a diminution of 2240 annually. When the late Dr Clark was a pupil at the Lying-in-Hospital in Dublin, his attention was directed to the frightful mortality amongst the infants, from what were called the nine-day fits, which destroyed no less than one in six. He ascribed it to overcrowding and deficient ventilation, and at his urgent request measures were adopted to remedy what was amiss. The mortality immediately diminished to 1 in 19½, and at the present day the disease may be said to be almost extinct.* In my *Treatise on the Management of Infancy*, I mention other facts of a similar nature which occurred in the Island of St Kilda, and in the Dublin House of Industry, in both of which places the efficacy of ventilation in reducing the mortality among the young was strikingly illustrated.

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* Heart of Mid-Lothian, vol. i., chap. 9, note.

The greater prevalence of consumption among females and persons leading a sedentary life within doors, and its comparative unfrequency among males, and especially among those who live much in the open air, also afford strong evidence that the habitual breathing of pure air, when combined with ordinary prudence in other respects, is one of the surest protections we can have against pulmonary disease.

With regard to the *temperature* and *dryness* of the air which we breathe, some precautions are necessary, especially in winter. When in the enjoyment of a nourishing diet and frequent and active exercise in the open air, the young are not very susceptible of cold. But when confined to the house and deprived of active exercise, as happens during winter in many seminaries, they suffer severely from sitting or sleeping in cold rooms. In such circumstances, chilliness of the surface, coldness of the feet, and a feeble circulation, are commonly complained of, and loudly demand indulgence in ample exercise in the open air, and the provision of a temperate atmosphere within doors. If these remedies be denied, permanent bad health, retarded development of the bodily system, and consumption, will frequently ensue.

Since the introduction of Arnott's and other stoves into churches and rooms, it has become doubly necessary to attend to the degree of *dryness* in the air we breathe. In its natural state, the air always contains more or less moisture, and the system is constituted with relation to that fact. When, however, a room is heated by a stove, the air which it contains is rendered far too dry for healthy respiration, and in that state, it acts injuriously both on the lining membrane of the air-cells and on the skin. On the Continent, where stoves are much used, a large vessel containing water is generally placed on the top to supply the necessary humidity by evaporation; and the plan answers very well, as the warmer the stove, the more rapid the evaporation. Dr Arnott very properly insists strongly on some such precaution being combined with the use of his stoves in this country.

A very *moist* atmosphere is also injurious. It impedes exhalation from, and stimulates absorption by, the lungs and skin, so that any deleterious impurity, such as miasma or contagion, is much more likely to be received into the system when floating in a moist air. This is one of the causes of the high mortality which prevails in narrow streets and closes; and hence the necessity of additional care in ensuring cleanliness in situations where damp prevails from the impeded action of the sun and wind. Hence again the necessity of drainage in our cities to ensure purity of the air. "There are," says Professor Williams, "few kinds of filth more offensive, few mephitic gases more foul, and few descriptions of offal more abominable than those which are excreted from the animal body itself. And if, as we have seen, such matters are so injurious when not sufficiently eliminated out of the body, it is not surprising that they continue to be noxious and may become causes of disease after they have been evacuated, if proper means be not taken to remove them. The necessity of self-purification is illustrated by the instinctive habits of many animals and birds, which take much pains to cleanse themselves and their young, and in many instances carefully remove excrements from their nests and habitations. Yet with strange disregard of all instinctive feelings, and indolent neglect of the plainest dictates of reason, human beings are found continually exposing themselves to the influence of their own accumulated filth, until disease is engendered and aggravated into pestilence, and the rate of mortality is doubled or tripled in the population."* A most striking and instructive instance of the deleterious action of fetid emanations from decomposing animal matter is reported by the Board of Health. Immediately opposite Christchurch Workhouse, Spitalfields, belonging to the Whitechapel Union, and only separated from it by a narrow lane, a few feet wide, there was, in 1848, a manufactory of artificial manure, in which the most abominable animal substances were desiccated by dry heat on a kiln, or sometimes by mere exposure of the compost to the action of the sun and air. "The workhouse contained about 400 children, and a few adult paupers. Whenever the works were actively carried on, particularly when the wind blew in the direction of the house, there were produced numerous cases of fever, of an intractable and typhoid form; a typhoid tendency to measles, smallpox, and other infantile diseases; and for some time a most unmanageable and fatal form of aphthæ of the mouth, ending in gangrene. From this cause alone 12 deaths took place among the infants in one quarter. In the month of December 1848, when cholera had already occurred in the Whitechapel Union, 60 of the children in the workhouse were suddenly seized with diarrhœa in the early morning. The proprietor was compelled to close his establishment, and the children returned to their usual health. Five months afterwards the works were recommenced; in a day or two subsequently, the wind blowing from the manufactory, a most powerful stench pervaded the workhouse. In the night following, 45 of the boys, whose dormitories directly faced the manufactory, were again suddenly seized with diarrhœa; whilst the girls, whose dormitories were in a more distant part, and faced another direction, escaped. The manufactory having been again suppressed, there has been no return of diarrhœa up to the present time."*

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* British and For. Med.-Chir. Rev., vol. iv., p. 365.

In connection with this subject we may fitly refer to the recent investigations of Professor Edmund Davy of Dublin on the "Use of Peat or Turf as a means of promoting the Public Health and Agriculture of the United Kingdom." The deodorising properties of peat in the form of charcoal have been for some time well known; but it occurred to the Professor, that as creosote, one of the most powerful antiseptics, is found in peat, the latter would prove efficacious without the charring. "Multiplied experiments," he observes, "on the most offensive putrid matters I could procure, more than realised my most sanguine expectations; and I have most clearly established the fact, that our common peat or turf, and turf-mould, in all their varieties of colour, as black, brown, red, &c., in all their changes of form, as solid, compact, fibrous, friable, &c.,—in what is sometimes called fluid peat, and at other times flow peat or quagmire, as they are all found in our bogs, but only sold in our shops as peat or turf, or peat-mould—have similar deodorising and disinfecting properties as when charred, and that these properties may be increased to a certain extent by the most simple and inexpensive means—namely, by separating water from it, either by exposure to the sun's rays in dry weather, or by artificial heat without charring it, and by reducing it to a state of minute division or fine powder."* These remarks deserve the attention of proprietors on whose estates peat is found; for, should the experiments of Professor Davy be confirmed, a material improvement may be effected at little cost in the sanitary condition of cottages, while the manure will be better preserved for the use of the land.

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* Principles of Medicine, 2d ed., p. 44. London, 1848.

* Report on Cholera by the Board of Health, p. 41.

The next method for promoting the health of the lungs has a direct reference to the second condition of healthy respiration, and consists in the *perfectly free expansion of the chest, so that the pure air which has been provided may have easy and full access to the air-cells of the lungs.* This condition of health implies not only that all external restraints upon the expansion of the chest shall be removed, but that, as a general rule, the mode of life shall be sufficiently active to ensure that full and deep respiration, without which the aëration of the blood cannot be adequately effected.

At all periods of life this condition of health is very important, but in youth, and especially during the rapid development of the organism, it may justly be said to be indispensable. The formation of a sound constitution will depend more upon its fulfilment than upon any other single condition; and yet, if we examine the prevailing methods of education and usages of society to ascertain how far it is acted upon, we shall find but little room for boasting, and much for disappointment. Instead of frequent intervals of varied and active exertion in the open air being made to divide the long periods of confinement and mental occupation to which the young are subjected, we find scarcely a moment left, or a change of position allowed, between one lesson and another. Even during the short time allotted for exercise, a formal monotonous walk, at a pace which leaves the breathing as limited and feeble as before, is often all the indulgence which is granted. In more mature life, the habit thus cultivated becomes confirmed, and many, especially females, spend their days in sedentary occupations and complete bodily inaction, which render freedom of respiration impossible. If, however, we regard the laws of the animal economy in their true light of clear expressions of the will of the all-wise Creator who instituted them, and not as mere emanations of the mind of man, we shall be much less likely to fall into errors of this kind, and far more anxious to carry the Divine intentions into practical effect.* The common notion is, that physiological principles and hygienic laws are the mere inventions of man, and that hence they may be attended to or neglected with equal impunity as if they really were so. This is a fatal mistake.

Not only, however, is general exercise or bodily activity required, to ensure the health of the lungs by the complete and effectual respiration which it necessitates, but the direct exercise of the lungs themselves is, when judiciously managed, one of the most efficacious means which we can employ for promoting their development and warding off their diseases. In this respect the organs of respiration closely resemble the muscles and all other organized parts. They are made to be used, and if they are left in habitual inactivity, their strength and health are unavoidably impaired; while, if their exercise be ill-timed or excessive, disease will as certainly follow.

The lungs may be exercised *indirectly* through such kinds of muscular exertion as occasion quicker and deeper breathing; and *directly* by the employment of the voice in speaking, singing, reading aloud, or crying. In general, both ought to be conjoined. But where the chief object is to improve the lungs, those kinds which have a tendency to expand the chest, and call the organs of respiration into play, ought to be especially preferred. Rowing a boat, fencing, quoits, cricket, shuttlecock, and the proper use of the skipping-rope, dumb-bells, and gymnastics, are of this description. All of them employ actively the muscles of the chest and trunk, and occasion in the lungs themselves a freer and fuller expansion. Climbing up hill is, for the same reason, an exercise of high utility in giving tone and freedom to the pulmonary functions.

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* Chambers's Journal, Feb. 11, 1851.

* See Chapter III.

Where, either from hereditary predisposition or accidental causes, the chest is unusually weak, every effort should be made, from infancy upwards, to favour the growth and strength of the lungs, by the habitual use of such of the above-mentioned exercises as can most easily be practised. The earlier they are resorted to, and the more steadily they are pursued, the more certainly will their beneficial results be experienced. In employing them, the principles explained in the chapter on the Muscles should be kept in view.

Habitual exercise in a hilly country, and the frequent ascent of acclivities, especially in pursuit of an object, are well known to have a powerful effect in *improving the wind* and strengthening the lungs; which is just another way of saying that they increase the capacity of the chest, promote free circulation through the pulmonary vessels, and lead to the more complete oxygenation of the blood. Hence the vigorous appetite, the increased muscular power, and the cheerfulness of mind so commonly felt by the invalid on his removal to the mountains. I was myself sensible of advantage from this kind of exercise during a Highland excursion. The necessity of frequent and deep inspirations, and the stimulus thus given to the general and pulmonary circulation, had an obvious effect in increasing the capacity of the lungs and the power of bearing exertion without fatigue. Even when I was wearied, the fatigue went off much sooner than after a walk of equal length on a level road, and was unattended with the langour which generally accompanied the latter. In fact, the most agreeable feeling which I experienced during the whole excursion was while resting after undergoing, in the ascent of a hill, a degree of exertion sufficient to accelerate the breathing, and bring out free perspiration. A lightness and activity of mind, and freedom about the chest, which I never felt to the same extent at any other time, followed such hilly walks, and made the fatigue comparatively light. Mountain-exercise constitutes one of the essential concomitants of the *water-cure;* and so necessary is it to the success of the system, that all attempts to carry it into full effect in level districts have failed. " We must have mountains," says Priessnitz, and the reader will now understand the reason for this necessity. A stimulus must be given to the vital metamorphoses, which the mere external or internal use of water cannot impart.

Before such exercise, however, can be resorted to with advantage, or even with safety, there must be nothing in the shape of active disease existing. If there be, its adoption will, in all probability, occasion the most serious injury. This also I experienced in my own case: for many months at an earlier stage of convalescence, going up a stair, ascending the most gentle acclivity, or speaking aloud for a few minutes, was equally fatiguing and hurtful, often bringing on cough, and occasionally a slight spitting of blood. All that time, riding on horseback, which exercises the body without hurrying the breathing, was especially useful. The advantage of these exercises in giving tone and capacity to the lungs, where debility rather than disease is complained of, is shewn in their being uniformly resorted to in preparing for the race-course and for the field. The true sportsman puts himself in training as well as his dog or his horse, and fits himself for the moors by regular excursions previously to the 12th of August. By so doing he improves his wind and increases his muscular strength to a remarkable extent in a very short time.

When no active pulmonary disease exists, these exercises may, with the best effects, be frequently carried so far as to induce free perspiration; only, great care should be taken not to remain inactive, but immediately to rub the surface of the body thoroughly dry, and to change the dress. It is quite ascertained that, with these precautions, perspiration from exercise is the reverse of debilitating. It equalizes and gently stimulates the circulation, relieves the internal organs, improves digestion, and invigorates the skin. Jackson testifies strongly to these results, when he declares that the severe exercise undergone in training, not only improves the lungs, but always renders the skin "quite clear, *even though formerly subject to eruptions.*"* These assertions are, of course, to be received as the statements of a man partial to his own art; but they are in accordance with experience, and with the laws of the animal functions, so far as these are known. They, therefore, merit the consideration of professional men, and of those whose features are often disfigured by eruptions which they find it difficult to remove by any kind of medicine.

I hardly need repeat, that, when wishing to favour the development of the lungs, we should be scrupulous in avoiding such positions of the body as hinder their full expansion. Tailors, shoemakers, clerks at a writing-desk, and the like, are unfavourably situated in this respect, as their bent position constrains the chest, and impedes the breathing and circulation.

Direct employment of the lungs in practising deep inspiration, speaking, reciting, singing, and playing on wind-instruments, is very influential for good or for evil, according as it is indulged in with or without due reference to the constitution of the individual. If it is properly managed and persevered in, particularly before the frame has become consolidated, nothing tends more to expand the chest, and give tone and health to the important organs contained in it; but if it is either ill-timed or carried to excess, nothing can be more detrimental to their health. In this respect, as well as morally, the introduction of singing into our common schools, as lately encouraged by Government, will prove an inestimable advantage; and I should rejoice to see it universally adopted as an essential part of physical, intellectual, and moral education, in all classes of society. To the poor, especially, it will supply a means of enjoyment and refinement which will do much to improve their condition, and diminish the attractions of the alehouse.* As a preventive of disease, Sir James Clark is in the habit of recommending the full expansion of the chest in the following manner: "We desire the young person, while standing, to throw his arms and shoulders back, and, while in this position, to inhale slowly as much air as he can, and repeat this exercise at short intervals, several times in succession; when this can be done in the open air, it is most desirable, a double advantage being thus obtained from the practice. Some exercise of this kind should be adopted daily by all young persons, more especially by those whose chests are narrow or deformed, and should be slowly and gradually increased."† In this recommendation I heartily concur.

On the same principle, even the crying and sobbing of children contribute to their future health, unless they are caused by disease, and carried to a very unusual extent. The loud laugh and noisy exclamations attending the sports of the young, have an evident relation to the same beneficial end; and ought therefore to be encouraged instead of repressed, as they often are by those who, forgetting that they themselves were once young, seem to expect in childhood the gravity and decorum of more advanced age. I have already noticed (p. 97) an instance on a large scale, in which the inmates of an institution were, for the purpose of preserving their health, shut up within the limits of their hall for six months, and not allowed to indulge in any noisy and romping sports. The aim of the directors was undoubtedly the purest benevolence, but, from their want of knowledge, the object was defeated, and the arrangement itself became the instrument of evil. They were ignorant that activity and respiration stand in direct relation to each other, and that muscular action, by promoting free respiration, ensures the normal performance of the vital metamorphoses of matter, which, in their turn, ensure an increase of animal heat and a pervading feeling of comfort.

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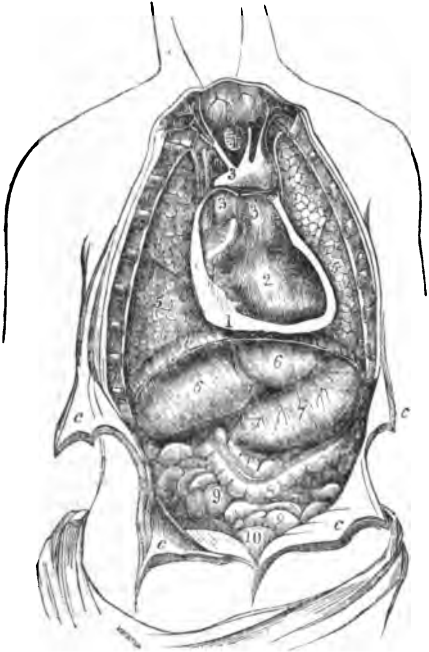
* Sir John Sinclair's Code of Health, 5th edition. Appendix, p. 37.

* It is pleasing to record that there has lately been erected in Edinburgh, chiefly at the expense of Lord Murray, a hall in which singing is to be taught, at a very cheap rate, as a branch of popular education. We sincerely trust that his Lordship's most laudable endeavour to benefit his fellow-citizens will be crowned with success.

† Clark on Consumption and Scrofula. p. 298.

Beneficial as the direct exercise of the lungs is thus shewn to be in strengthening the chest, its influence extends still farther. If we examine the position of the lungs as indicated by the numerals (5, 5) in Fig. 16 (taken from Dr Southwood Smith's *Philosophy of Health*), we shall see, that, when fully inflated, they must necessarily push downwards and flatten the moveable arch of the diaphragm (*h*), by which they are separated from the belly or abdomen. This alteration, however, cannot take

Fig. 16.



place without the diaphragm in its turn pushing down the liver (6), stomach (7), and bowels (8, 9), which it accordingly does, causing them to project forwards and sidewards.* But no sooner are the lungs fully inflated, than the contained air is again thrown out. The lungs diminish in size, the diaphragm rises, and with it all the contents of the abdomen return to their former position. The whole digestive apparatus is thus subjected to a continual pressure and change of place; and the stimulus thence arising is in truth essential to the healthy performance of the digestive functions, and is one of the means arranged by the Creator for the purpose. Consequently, if the lungs be rarely called into active exercise, not only do *they* suffer, but, an important aid to digestion being withdrawn, the *stomach* and *bowels* also become weakened, and indigestion and costiveness ensue. I have already alluded to this subject in the chapter on muscular exercise, and have also considered it in detail in my work *On Digestion and Diet;* but the general principle will be sufficiently understood from inspection of the above figure.

After this exposition I hardly need say that the loud and distinct speaking enforced in many public schools is productive of much good to the young, and that the lessons in singing now to be carried into effect in other institutions besides Infant Schools are much to be commended. Let any one who doubts their efficacy as exercises of the lungs, attend to what passes in his own body on reading aloud a single paragraph, and he will find not only that deep inspirations and full expirations are encouraged, but that a considerable impulse is communicated to the bowels; affording a marked contrast to the slight breathing and quiescent posture of those whose voices never rise above a whisper.

Reading aloud, public speaking, and lecturing, are excellent exercises for developing the lungs and the chest. But, as they require some exertion, they ought to be indulged in with prudence, and with constant reference to the constitution and health of the individual. The reviewer of a former edition of the present volume (himself a lecturer), in noticing this part of the book, adds the following testimony:—"We know, ourselves, from personal experience, that, often when preparing to go to lecture, a languor has crept upon us, inducing an unwillingness to exert ourselves. We have gone,—the lecture has commenced,—the mind was called into action,—a perspiration broke forth on the brow,—the circulation was equalised,—and, at the conclusion of the lecture, the languor was gone." Hence he recommends "reading to one's family in the evening," as "an excellent practice, and one tending much to sweeten social life."* When early resorted to and steadily persevered in, such exercises are very useful in warding off disease, and strengthening an important function. But when begun suddenly, and carried to excess by persons with weak lungs, they are more directly injurious than almost any other cause. It is not uncommon for young divines to make excessive exertions in preaching, without any preparation for the effort which it requires; and to experience, in consequence, pains in the chest, spitting of blood, and other dangerous forms of disease, which often extinguish their brightest prospects in the morning of life. Sacrifices of this kind are the more to be lamented, because it is probable that, by a well-planned system of gradual preparation, many who fall victims might find in their profession even a source of safety.

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* The following are additional explanations of the figure:—

a a a. The cut edges of the ribs, forming the lateral boundaries of the cavity of the chest.

c c c c. The cut edges of the abdominal muscles, turned aside, exposing the general cavity of the abdomen.

1. The cut edge of the pericardium, or membrane inclosing the heart, turned aside.

2. The heart.

3 3 3. The great vessels in immediate connection with the heart.

4. The trachea, or windpipe.

6 6. The liver.

he stomach.

large intestine.

e small intestines.

urinary bladder.

* London Medical and Surgical Journal, No. 134, p. 107.

The late illustrious Cuvier, as was mentioned at page 126, is considered to have been saved from an early death, by his appointment to a professorship leading him to the moderate and regular exercise of his lungs in teaching—a practice that soon removed the delicacy of chest to which he was subject, and enabled him to pass uninjured through a long and active life. Other examples of the same kind might be mentioned. But it is important to observe, that in all of them the exercise was always accurately proportioned to the existing state of the lungs. Had active disease existed, or the exertion required been beyond what the lungs were fully able to bear, the effect would have been, not to improve health, but to destroy life; and this condition of accurate relation between the amount of exercise and the state of the organism must never for a moment be overlooked. With a little care, however, the point at which direct exercise of the lungs ought to stop may easily be determined by observing its effects.

The same principle leads to another obvious rule: When disease of any kind exists in the chest, exercise of the lungs in speaking, reading, and singing, and also in ordinary muscular exertion, ought either to be entirely refrained from, or strictly regulated by professional advice. When a joint is sore or inflamed, we know that motion impedes its recovery. When the eye is affected, we for a similar reason shut out the light; and when the stomach is disordered, we have respect to its condition, and become more careful about diet. The lungs demand a treatment founded on the same general principle. If they are inflamed, they must be exercised as little as possible, otherwise mischief will ensue. Hence, in a common cold of any severity, silence, which is the absence of direct pulmonary exercise, ought to be preserved, and will, in truth, be its own reward. In severe cases, and in acute inflammations of the chest, this rule is of the greatest importance. It is common to meet with patients who cannot speak three words without exciting a fit of coughing, and who, notwithstanding, cannot be persuaded that speaking retards their recovery. In like manner, in spitting of blood, and in the early stage of tubercular consumption, when the breathing cannot be excited without direct mischief, it is often difficult to convince either the patient or his friends of the necessity of silence. He perhaps does not feel pain on attempting to speak, and says that "it merely raises a short tickling cough, which is nothing." But if he persists, dearly bought experience will teach him his error, and dispose him to regret, as did a lamented friend of the author, that a few weeks out of the years which he had dedicated to the study of the classics had not been devoted to the acquisition of some little knowledge of the structure and functions of his own body. In the instance alluded to, after spitting of blood had been induced by severe bodily labour, the patient continued talking almost the whole day to the visitors and inmates of a large public establishment, and believed himself all the time to be very careful, as he said he was no longer exerting his body. When the error was pointed out, and the mechanism of the lungs explained to him, he deeply bewailed the ignorance which had allowed him to act in a manner so pernicious.*

All violent exercise ought, for similar reasons, to be refrained from, during at least the active stages of cold. Everything which hurries the breathing, whether walking fast, ascending an acclivity, or reading aloud, has the same effect on the diseased lungs that motion of the bone has on an inflamed joint. It seems to me, that many people hurt themselves much more by the active exercise they take during a severe cold than by the mere exposure to the weather. It is well known that a person, when suffering from inflammatory cold, may go out for a short time even in an open carriage more safely than on foot; and there is much reason to believe, that it is the absence of active exercise of the lungs in the former case, which makes the exposure less hurtful. In chronic coughs, on the contrary, when there is no pulmonary excitement, carriage exercise, by chilling the surface, is apt to increase the expectoration; while a gentle walk, by stimulating the action of the skin, diminishes it.

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* The patient here referred to was Mr Abram Combe, the author's brother. See Life and Correspondence of Dr Combe, p. 142.—Ed.

After all active disease has been subdued, or when nothing but delicacy remains, the adequate exercise of the lungs is one of the best means of promoting effectual recovery. Those parents, therefore, act most erroneously, who, in their apprehensive anxiety for the protection of their delicate children, scrupulously prohibit them from every kind of exercise which requires the least effort, and shut them up from the open air during winter, in the delusive hope of thus warding off cold and protecting their lungs. I have seen the greatest delicacy of constitution thus engendered, especially when an undue quantity of warm clothing was at the same time employed. When tested by the principles above explained, such conduct is found to be as ill adapted as possible to the end in view, and utterly at variance with the laws of the animal economy.

Considering the delicacy and extent of the lining membrane of the lungs, and the ready access to it which the external air has, it cannot be a matter of surprise that sudden or great changes in the atmospheric temperature or constitution should often operate injuriously on the lungs, and be the means of inducing not only colds but more serious disease. During respiration the inhaled air, except when very cold, acquires a temperature closely approaching to that of the body, and thus carries off a larger proportion of caloric, the lower its temperature when inhaled. Valentin found, for instance, that when the temperature of the inspired air was 20° F., that of the expired air was 85°, shewing an acquired temperature of 65°; while, when inhaled at 70°, it was exhaled at 99°, shewing an increase of only 29°, and a corresponding saving of caloric to the body.* We here see why an invalid whose heat-producing powers are low should be liable to suffer from exposure to a cold atmosphere even when warmly clad; an amount of caloric is carried off by the breath, beyond the powers of the system to replace. The proportion of the total heat generated in the body which is given off by the lungs in heating the air of respiration, has been variously estimated by different physiologists. According to Barral it amounts to 7·3 per cent., and to Valentin to 8·5 per cent.; but these estimates rest upon very uncertain data, which necessarily vary with the atmospheric temperature.† The temperature of the air most congenial to delicate lungs lies between 60° and 70°; the breath then marks precisely the temperature of the blood, and the inhaled air thus cannot have any depressing effect upon the respiratory organs by lowering their temperature; while it is sufficiently cool to allow, by its expansion in the lungs, of a due amount of aqueous vapour being carried off. It is a curious fact, but one quite in accordance with the laws which govern the temperature of the body, that when hot air is inspired it is exhaled at a diminished temperature. Thus Valentin found that air at 107° was reduced to 100°; precisely the same degree of heat that was marked when the temperature of the inhaled air was 70°. From these facts the reader will learn the propriety of diminishing, especially in delicate subjects, the risk of sudden transitions, by breathing through several folds of woollen fabric or silk when obliged to pass from a warm room to the cold external air, or to breathe a cold or damp air for a length of time. The cold air becomes partially heated and deprived of its moisture in passing through such a medium, and the protection thus afforded is so evident that few who have tried the precaution will ever afterwards neglect it. Since these remarks were first published, a very ingenious instrument has been contrived by Mr Jeffreys of London, for wearing over the mouth and preserving a uniform temperature in the air we breathe, even in passing from a warm drawing-room to a cold wintry atmosphere. From personal experience, as well as observation of its effects on others, I can speak very favourably of its usefulness for pulmonary invalids, and for persons who suffer from delicacy in any part of the air-passages. The instrument is called "Jeffreys' Respirator," and consists of two or three plates of fine closely-set wire, through the interstices of which the breath passes. The heat which the wire receives from the breath is imparted to the inhaled air, the temperature of which is thus increased; and this increase is greater or less according to the number of the plates of wire.

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* Lehrbuch, vol. i., p. 584.

† Wagner's Handwörterbuch, Band IV., p. 73.

Perhaps the most important time in the life of a person born with a predisposition to consumption is that of puberty, comprising from the commencement of rapid growth to the full consolidation of the system about or after the twenty-fourth year. In most young people, the transition from adolescence to maturity is so rapid, that for two or three years all the animal powers are tasked to enable nutrition to keep pace with growth, and a corresponding debility of both body and mind is often observed to co-exist, indicating in the clearest manner the necessity of a temporary remission from such studies and occupations as require much mental exertion or confinement within doors. The development and health of the physical system ought then to be almost exclusively attended to; and when the body has acquired its solidity, the mental faculties will again become active. I have seen instances where a knowledge of the latter fact afforded substantial consolation to young men who, while their bodies were growing rapidly, were apt to become despondent, on account of the unusual sluggishness and inefficiency of their intellectual powers. After a few years, when growth and consolidation were completed, the brain vigorously resumed its functions.

In such circumstances, relaxation from study, residence in the country, exercise in the open air, plenty of nourishment, and freedom from care, will often do great good, if sufficiently persisted in, and go far to protect the patient against the future invasion of consumption.—Whereas, if, under the mistaken notion that such precautionary measures are a waste of time, a delicate growing youth is allowed to continue at his studies or his desk till disease has actually commenced, the disappointed parent may discover that it is too late to take alarm when health is gone.

I am desirous to draw the attention of parents to this subject, because a good deal of observation has satisfied me that too little regard is paid to the *preservation* of health at this critical period of life, and that, by proper management during the transition from adolescence to maturity, many who now fall victims might be saved. The statistical returns of large towns shew, that, especially in the male sex, the period between seventeen and twenty-four years of age is really, as described by a late careful investigator of the laws of mortality, "one of restlessness, toil, and danger; the human faculties are then exercised to the utmost, and life is more freely expended than at any other season."* Taking Paris for an example, we find that, according to the census of 1816, the population of this city included between—

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* On the Natural and Mathematical Laws concerning Population, Vitality, and Mortality. By Francis Corbaux. P. 92.

10 & 15 years of age.	15 & 20 years of age.	20 & 25 years of age.	25 & 30 years of age.
M. 22,995. F. 24,373.	M. 32,621. F. 35,724.	M. 26,582. F. 30,375.	M. 27,019. F. 35,957.

while the mortality was as follows:—

	Between 10—15.		15—20.		20—25.		25—30.	
	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.
1812	189	174	323	364	410	342	293	436
1813	146	140	439	234	553	307	314	400
1814	210	200	1198	322	1060	393	555	456
1815	182	182	314	266	331	447	312	396
1816	144	188	255	293	286	381	230	362
1817	236	268	431	388	609	455	358	436
1818	221	224	403	409	451	462	280	465
	1328	1376	3363	2296	3700	2787	2342	2951

This table, which is compiled from a French journal,* shews a remarkable increase in the number of deaths between 15 and 20, over those between 10 and 15; and again another increase in the male mortality in those between 20 and 25 over those between 25 and 30. In the females, from circumstances which it is unnecessary to explain here, the period of increased mortality extends to 30 years of age.

These statistics, especially when the excess of female population is borne in mind, place in a striking point of view the dangers of the state of transition from youth to manhood, especially amidst the temptations of a luxurious capital; and the necessity of attempting, by early instruction and timely prudence, to protect the young against the numerous causes of disease which then come into active and fatal operation. They ought also to serve as a warning to those who, in the spring-time of life, are inclined to trust implicitly for their safety to the strength of a good constitution, and to despise the prudence which dictates the avoidance of unnecessary exposure. And they shew, in a manner not less forcible, the evils consequent on war, in the high male mortality of the year 1814, when Paris was occupied by the allied forces.

The early maximum of mortality in the male sex, especially in cities, is explicable by the fact, that it is at the approach of manhood, when both mind and body are in a state of transition, that dissipation is most indulged in, and presses with its deadliest force. Many delicate youths are carried off, who would have escaped without injury, if they could have been persuaded to act with prudence during these two or three critical years. Many, I am constrained to say, first learn the means of their destruction in boarding-schools and places of public resort, and that often when no mischief is suspected by their respectable teachers. On this topic, however, the non-professional character of the present work precludes me from entering into details.

There is another requisite for the permanent health of the lungs, to which sufficient weight is far from being attached in society, and which

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* Annales d'Hygiène Publique, July 1850.

I can scarcely urge too strongly upon the attention of parents and the guardians of the young, as well as of the young themselves. I allude to the influence of the original constitution of the lungs.

Universal experience shows that the ordinary assimilating processes act by fashioning the nutritive material according to certain laws received from the model or ancestor. The germ of the Hindoo or Negro receives from the parent certain immutable specific characters, and is invariably developed into a Hindoo or Negro; and according to precisely analogous, though more mutable laws, the germ derived from consumptive parents is developed into an individual liable to consumption. This truth is practically recognised by insurance companies, which reject, without hesitation, individuals whose parents died of this disease. But in consumption, the type according to which the nutritive material is fashioned, is less determined and specific than in the Hindoo or Negro, because in this latter instance the variation of the type is not one of disease; whereas in consumption it is a variation from a normal standard, which the inherent powers of the system are continually striving to overcome. If, therefore, an individual of a consumptive family be placed in circumstances extremely favourable to health, the tendency to the disease may be conquered; but if foul air, excess or deficiency of diet, or the abuse of stimulants be allowed to impair the nutritive powers, a depraved condition of the blood then ensues, which most certainly passes into consumption. Accordingly, no fact in medicine is better established than that which proves the hereditary transmission from parents to children of a constitutional liability to pulmonary disease, and especially to consumption; yet no condition is less attended to in forming matrimonial engagements. The children of scrofulous and consumptive parents are generally precocious, and their minds being early matured, they engage early in the business of life, and often enter the married state before their bodily frame has had time to consolidate. For a few years, everything seems to go on prosperously, and a numerous family gathers around them. All at once, however, even while youth remains, their physical powers begin to give way, and they drop prematurely into the grave, exhausted by consumption, and leaving children behind them, destined in all probability either to be cut off as they approach maturity, or to run through the same delusive and fatal career.

Many examples of this kind might be pointed out among the higher classes of society, who are not restrained from following their predominant inclinations by any necessity of seeking subsistence in professional pursuits. And many instances might be referred to, in which no regard was shewn to the manifest existence of the same disposition in the family of either parent, and in which, consequently, the married state was embittered either by barrenness, which is then the most favourable result, or by the prevalence of disease and delicacy in the progeny. It may not be easy to enforce upon the young and inexperienced the requisite degree of attention to these circumstances; but surely education, especially when backed by example, might do much, if the young were properly instructed at an early period in the leading facts and principles of the human constitution. Where hereditary precocity and delicacy of frame exist, marriage, instead of being hastened, ought invariably to be delayed at least till the fullest maturity and consolidation of the system; otherwise the consequences will be equally unhappy for the individual and for his progeny. From the fact of the large number of young married people who suffer from consumption, Dr Walshe* inferred that there is a greater "proneness to early marriage" among the consumptive of both sexes; but the reasons above stated seem to us to render it more probable that a "greater proneness to consumption" among the early married of both sexes is the correct inference from the fact referred to. During growth and for a considerable time afterwards, the constitution is still imperfect even in healthy subjects, and wants the enduring strength which it acquires in mature age, and the possession of which marks the period which Nature has fixed for the exercise of the functions of reproduction. Many young people of both sexes fall sacrifices to early marriage, who might have withstood the ordinary risks of life, and lived together in happiness, if they had delayed their union for a few years, and allowed time for the consolidation of their constitutions. These remarks are confirmed by the returns of the French army, which shew that the young recruits, who join at 20, are much less able to withstand injurious influences than older soldiers whose systems have become consolidated. During the first years of service the mortality amounts to 7½ per cent., during the second to 6½ per cent., and gradually decreases to 2 per cent. during the sixth and seventh years.*

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* First Medical Report of the Hospital for Consumption.

I have urged this point strongly, because hereditary predisposition is, avowedly and beyond all doubt, a frequent source of the more serious forms of pulmonary disease, and it would be worse than folly to allow past and painful experience to go for nothing. Medical men have much in their power in preventing such violations of the laws of the Creator, at least where they are regarded, as they should always be, as the friends not less than the professional advisers of the family. An instructive example of the influence of the mother on the health of progeny is afforded by the relative mortality of Jewish and Christian infants in Prussia. Jewesses there seldom work in factories, and least of all when pregnant, or having the care of very young children. This custom gives the Jewish population such an advantage in point of health, that whereas in every 100,000 Christians born, there are 3569 still-born, there are only 2524 in the same number of the Jews; while out of 100,000 infants of Christian parentage, 17,413 die in the first year, but only 12,935 in 100,000 of the Jewish race.†

In connection with this subject, I may mention that Sir James Clark has the merit of having drawn attention to the important fact, that a state of impaired health in the parent, *whether constitutional or acquired*, and particularly if caused by imperfect digestion and assimilation, is as productive of a tendency to scrofula and consumption in the children as if it had descended by hereditary transmission. If parents in general were duly impressed with the truth and bearing of this fact, many of them might be induced, on account of their children, to take that rational care of their own health which they seem to be incapable of doing for their own sake.

The last requisite for the health of the lungs which I need mention here is *a due supply of rich and healthy blood*. When, from defective food, or impaired digestion, the blood is impoverished in quality, and rendered unfit for adequate nutrition, the lungs speedily suffer, and that often to a fatal extent. So certain is this fact, that, in the lower animals, *tubercles* (the cause of incurable consumption) *can be produced in the lungs to almost any extent, by withholding a sufficiency of nourishing food, and by causing them to breathe a vitiated atmosphere.* The same circumstances operate to a lamentable extent among the poorly fed population of our manufacturing towns; whereas it is proverbial that butchers—a class of men who eat animal food twice or thrice a day, and live much in the open air—are almost exempt from pulmonary consumption. Among the higher classes, again, the blood is impoverished, and the lungs are injured, not from want of food, but *from want of the power of adequately digesting it;* and hence we find, in every treatise on consumption, a section devoted specially to "*dyspeptic phthisis*," as it is called, or simply "consumption from bad digestion." The late hours, heavy meals, and deficient exercise, which are so generally complained of, but still so regularly adhered to in society, are the chief sources of many of these evils.

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* Annales d'Hygiène Publique, April 1849, p. 292.

† Annales d'Hygiène Publique, July 1850, p. 23.

The ultimate end of digestion, it ought ever to be remembered, is to prepare the vital fluid from which all the organs of the body are formed; and the blood cannot be duly elaborated without a free and copious supply of oxygen being presented to it in the lungs. In this country, exercise is seldom taken by the upper classes after dinner; and, consequently, the product of the digestion of the principal meal of the day does not receive the supply of oxygen requisite for its conversion into perfect blood. This, we believe, is one of the chief causes of gout, and other diseases dependent on imperfect assimilation; and hence one of the advantages of an early dinner is its allowing time for exercise in the open air, after digestion has advanced a certain way—in order that the new materials of the blood may be perfectly assimilated, and thus that depraved condition of the nutritive material which induces tubercles and other diseased products may be guarded against.

Before quitting this important subject, I may add another word of advice, in regard to those who are predisposed to consumption or weakness of the chest. As soon as active growth commences, permanent benefit may be derived from removal, for a few years, to a milder and less variable climate. Many who are sent abroad only to die painfully in a foreign land, in the noonday of life, might live for years in the enjoyment of health and usefulness, were they sent abroad *before* the appearance of disease, instead of after its unequivocal commencement. The previous delicacy, whence the susceptibility to colds and pulmonary affections arises, ought to attract the earliest attention, and excite the most persevering efforts for its removal. If it be allowed to make progress till consumption has commenced, medicine may come armed with its most powerful remedies, and directed by the most consummate skill; but it will too often come in vain. The rage which now prevails for mere intellectual education, and the utter neglect of the bodily health, to which it leads, is too often carried so far as to be a curse rather than a blessing; and till its fury be moderated by an increase of good sense in the parents, great mischief must, I fear, continue to ensue.

I cannot conclude this chapter without again referring the reader to Sir James Clark's work on Consumption and Scrofula, as affording, I may almost say for the first time, a comprehensive, philosophical, and practical view of the causes, nature, and treatment of consumption. The able author has not, it is true, greatly extended our power over that fatal disease in its most advanced periods; but he has done more to throw light upon its causes, to obviate its development, and to arrest it in its incipient stages, than any author with whose writings I am acquainted.

CHAPTER XII.

THE BRAIN AND NERVES CONSIDERED IN RELATION TO THE REST OF THE BODY AND TO THE MENTAL FACULTIES.

THE more carefully we investigate the nature and objects of the human constitution, it becomes only the more evident that THE MIND, which feels, and perceives, and thinks, and directs, is, so to speak, the truly human or characteristic portion of our being, and that the whole corporeal frame is constructed with direct reference to its properties and wants; or, in other words, that *subservience to the purposes of the mind is the fundamental principle on which the bodily organism has been fashioned.*

Placed as we are in a material world, acted upon at every moment of our lives by material objects, and requiring to act upon them in return, a material organism is indispensable for the operations of mind. Accordingly, we know mind only as it exists and acts during life in combination with the living organism, and can no more form a conception of its abstract qualities as disjoined from the body than we can of the principle of gravitation as separated from matter.

Palpable and undeniable as this great truth is, and universally as it is admitted in the abstract, there is, and always has been, a strange tendency in mankind to shrink from its contemplation as a practical proposition, and from accepting its legitimate consequences. Not remembering that, if it be so, "the thing is of God," and therefore good, many have entertained an apprehension that if the mind be admitted to be under the influence of the organism during life, its eternal existence must be thereby rendered doubtful. But such a fear displays a lamentable distrust of the omnipotence and wisdom of God. If, in the first place, the evidence be sufficient to demonstrate the fact that, during life, the mind acts by means of, and is acted upon by, material organs, we have no choice but to believe it, and to make the most of it for our own advantage. To shut our eyes to the perception of it, or our understandings to its consequences, cannot alter the reality, or undo that which God has seen right to ordain. If, again, we reject the fact, on the ground that it implies the impossibility of continued existence in another world, our distrust becomes mixed up with the grossest presumption which a fallible creature can shew towards its infallible Creator. Reason tells us that the future destiny of the mind or soul depends wholly on the will or *fiat* of the Almighty, and not in the very least on its own nature or essence. Whether material or immaterial, it is equally capable of either receiving or not receiving at His hands an eternity of existence.

Individually, therefore, I attach no importance to this long-agitated question, but rely with unshaken constancy on God having given to the human being, in mind as in body, that constitution which He saw to be best fitted to his destiny, whatever this may be.

As, then, every faculty or quality, by which man is distinguished from the rest of the animal creation, is possessed, and acts, in immediate connection with some corresponding peculiarity of organization, it follows that the structure of the human being must be as superior to that of the lower animals as the elevated qualities of man are to the instincts and limited capacities of the brutes. To ascertain how far this inference is well founded, let us shortly inquire what the qualities are by which man is characterised, and with what parts of the organism these qualities are more immediately connected.

For the elucidation of the first point, we have only to reflect upon what passes through the mind when we wish to form or to communicate a correct opinion of any historical personage or private friend whose worth and character we are anxious to see duly appreciated by others. Instinctively we fix at once upon the QUALITIES OF THE MIND—the peculiar combination of affections and moral and intellectual excellencies which we believe him to possess—as constituting the features which distinguish him from other men, and give him a claim to our regard. Knowing mind in this world only as it exists in connection with the living organism, we, no doubt, always associate these mental endowments with some form of body and peculiarity of features; but in the very act of doing so, we are still perfectly conscious that it is the *stamp of mind* imprinted on them which constitutes their chief attraction, and which, more than any merely physical advantage, gives to man his acknowledged superiority over the rest of the animal kingdom. Accordingly, when we warmly recommend one friend to another, we never think of saying, Love him because he is six feet high, or because he has a

Roman nose, a Grecian mouth, fine eyes, or a well turned limb. Allowing all these personal advantages (which in themselves are not to be despised) to make their own impression, we instinctively feel that they constitute a very unstable foundation for esteem and confidence, and rest our claims on his intelligence, prudence, benevolence, and integrity; certain that, if we succeed in establishing the *intellectual and moral excellence* of our friend, we shall serve him far more effectually than if we could prove him to possess the grace and symmetry of an Apollo or an Adonis.

The mind being thus the ruling principle or power for the use of which the whole bodily organism has been designed, it follows, that, whatever injury the body may sustain in other respects, so long as those parts of it which minister directly to the intellectual and moral faculties remain entire and in health, the human being will continue in undiminished possession of all the qualities for which we really value him, and by which he is distinguished from creatures of a lower grade. Thus, a person may be born without arms or legs, be almost as incapable of locomotion, and even more incapable of supplying his own wants, than the oyster within its shell, and yet excel in every moral and intellectual attribute for which humanity is prized. So also a friend may lose one or more of his limbs, or his body be disfigured by accident or disease; but while his *mind* remains, with its affections as warm, its moral feelings as active and pure, and its intellectual powers as vigorous as before, we recognise his identity, love him with the same ardour, rely upon him with the same unfaltering constancy, and rate his worth as highly, as when his form was distinguished for its symmetry, and every motion for its gracefulness and ease.—Since this remark was written, a beautiful example of its truth has appeared in the newspapers, under the not inappropriate title of an "*Exquisite Anecdote of Woman's Affection.*" It is stated that "Sir Robert Barclay, who commanded the British squadron in the battle of Lake Erie, was fearfully mutilated by the wounds he received in that action, having lost his right arm and one of his legs. Previously to his leaving England, he was engaged to a young lady, to whom he was most tenderly attached. Feeling acutely, on his return, that he was a mere wreck, he sent a friend to the lady, informing her of his mutilated condition, and generously offering to release her from her engagement. 'Tell him,' replied the noble girl, 'that *I will joyfully marry him, if he only has enough of body left to hold his soul!*'" The appositeness of this illustration is too obvious to require any comment.

In cases of disease it is truly astonishing how much of animal existence may occasionally be destroyed, leaving an intelligent being encased, as it were, in a living tomb. Of such cases the following instance related by M. Keratry is one of the most remarkable on record. "There is now living," he says, "in the department of the Isle and Vilaine, a person who, having been blind for ten years, lost also the sense of hearing, and in a little time afterwards became almost universally paralytic. He was entirely deprived of the use of his arms, legs, thighs, and of the whole exterior surface of the body, with the exception of a part of the face; but the power of speech, and the functions of respiration, circulation, and digestion remained. Under these deplorable circumstances he is not wholly without consolation; for a sort of intercourse is preserved with his family and friends, by means of characters traced on that part which still retains its sensibility, and in this state of unexampled misery he retains, in some degree, the distinguishing character of man—intelligence."*

If, then, the mind be the directing power for the use of which the bodily organism was originally designed by the omniscient Creator, and if the limbs, which act as the executors of its will, may be removed or rendered incapable of action, and yet the powers and capacities of the mind itself remain unimpaired, it necessarily follows that these parts cannot be directly essential to its integrity, and that for the various purposes of perception, thought, and feeling, the mind must be in immediate connection with some other portion of the body, which not only remains entire amidst so much destruction, but also must be so placed and so constituted as to maintain a communication with, and exercise an influence upon, all other parts of the body. Such accordingly is the fact, and by universal consent THE BRAIN is now admitted to be the immediate organ of the mind—the seat of emotion, perception, and thought; and *the nerves* which connect it with the rest of the body are ascertained to be the means by which it maintains its communication with the external world, and exercises an influence over all the other functions. Hence the deep interest which attaches to the study of the nervous system, and which renders an accurate acquaintance with its functions and laws of action so useful to every one engaged in the great work of human improvement.

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* Dr Cooke on Palsy, as quoted by Dr Graves, Clin. Lect., vol. i., p. 509.

To many of my readers it may seem needless to enforce, at so much length, a proposition which, in its abstract form, nobody thinks of denying; but unfortunately, there is a vital difference between *admitting theoretically* that the mental powers cannot act during life except through the medium of their appropriate organs, and *adopting the same great truth as a practical principle*, to be applied in the daily conduct of life, and in the education and general treatment of the young. Turn where we will, to the best authors on education, to the most highly gifted and experienced of our physicians and teachers, and to the purest and most sincere among the moral and religious guides of the young, we find (with a few honourable exceptions) each and all of them thinking and acting as if the minds under their charge were, even in this life, abstract and separate entities, entirely independent of the influence of the body. They study the mind and try to discover its laws, altogether without regard to the properties of the living organism with which God has connected it. In so doing they proceed much in the same way as if, in physics, we were to investigate the nature and laws of caloric, without paying any regard to the properties and modifying influence of the bodies in combination with which alone caloric can come under the cognizance of our senses; and yet we are daily surrounded by the most conclusive and even startling evidence that the mental functions are as immediately affected by the condition of the organs which execute them, as the action of caloric is by the properties of the objects with which it is combined.

If, then, we really wish to obtain consistent and useful results in the investigation of mind, this is not the way in which we ought to proceed. As we cannot alter the constitution which God has given us, it behoves us to study its nature and laws as He has presented it to us, combined with and influenced by a living organism, —in short, to follow the same course which has been so successfully pursued in our researches into other departments of science. It is long since Bacon demonstrated that the inductive method of inquiry is the only one which can avail us; and since mere speculation on mind has been tried for two thousand years, and tried in vain, why should we be longer deterred from entering upon the only path which can lead to success in the investigation of *mental*, as well as of *physical* nature ?

In inquiring into the mutual relations of the mind and body, the great leading fact which ought never to be lost sight of is, that one part of the organism—namely, the *brain*—is directly appropriated to what may be called the *central* or *internal* operations of mind, such as perception, emotion, thought, and judgment; and that other parts—the muscles and bones, *or organs of voluntary motion*

—are appropriated to what may be called its *external* operations, viz., executing externally the commands of the will. Palpable as the distinction between these two classes of operations is, it has, strange to say, been often overlooked; and hence certain philosophers have gravely contended that man owes all his mental superiority to the perfection of his hands. The propounders of this most untenable doctrine overlook the fact, that the hands are useful only in proportion to the intelligence and skill of the mind which directs them, and that the well-formed hands of an idiot are of no advantage to him, and impart to him none of the mental power of which he stands so much in need. Accordingly, the more carefully we inquire, the more certain will it appear that it is not by any perfection of the merely secondary instruments of voluntary motion, but by the superiority of mind in concomitance with superiority of brain, that man is distinguished from all other animals. It is the mind which is the truly human portion of our being; and in man the mind is conjoined with a more perfect and complicated brain than we discover in other animals, simply because he is remarkable above them all for the variety and extent of the faculties with which he is endowed. It is true that he possesses executive instruments, also far superior to those of other creatures; but it is not to these he owes his high position in the scale of creation. They are given him only to place him in harmony with his own elevated mind; and if the instruments which it employs to effect its purposes were not perfect in proportion, he would be constantly fretting under the conception of plans and designs which he had not the means of either fulfilling or communicating—and this would form a singular exception to the wisdom and benevolence displayed in all the other works of God.

The same subservience of the organism to the capacities and instincts is observable throughout the whole animal kingdom. In proportion as the intelligence of an animal is limited and its instincts are few, its brain is observed to be simple and rude, and its executive instruments correspondingly few and imperfect. The brain and the four legs and cloven feet of the sheep, for example, are in exact accordance with its limited faculties and desires; whereas, had they been joined to reasoning powers and moral sentiments like man's, what a miserable incongruity would have been the result! Or even supposing the form of the sheep to have been conferred upon a creature possessing the brain and ferocious impulses of the tiger, speedy destruction must have been its inevitable end. In like manner, if the towering instincts of the eagle had been united to the long legs and small wings of the ostrich, how utterly incongruous would the gift have been! Throughout the whole animal creation, accordingly, we find *the bodily structure invariably fashioned according to the instincts and kind of intelligence* with which each species is endowed. If the antelope bounds over the plain with the speed of a racehorse, it is not merely because it has long legs; but it has long legs and great activity to enable it to obey and live in harmony with its own natural instincts. If along with its present form and activity it had possessed the instincts of the sloth, and been doomed to remain upon a single tree till it had eaten up all the leaves, it would have been the most miserable of animals; and again, if the sloth, with its present form, were suddenly endowed with the instincts of the antelope, and impelled to scour the plain in search of food, it also would be a most wretched creature, because its claws and limbs are fashioned for climbing and holding fast, and not at all for running. Or, to pursue the parallel to an extreme, if the oyster, which has neither legs nor arms, because it has no sphere of action beyond its shell, and no faculties impelling it to change its place, were to become endowed with a human mind and feelings, in what a condition would it be placed! and on the other hand, if the human body were animated only by the instincts of an oyster, what would become of all its admirable and complicated mechanism, and of the happiness of man?

Having thus shewn that subservience to the purposes of the mind is the fundamental principle on which the bodily organism has been designed and constructed, I shall add a few remarks concerning the only remaining group of organs required to complete the animal frame, and which are but *indirectly* essential to the mental functions—I allude to those by which nutrition is carried on, and the life of the whole body sustained. In one respect, these stand in much the same relation to the immediate organs of the mind that the steam in a steam-engine does to the executive machinery. The spinning-jenny is the *direct* producer of the thread; but without the essential though indirect aid of the steam to keep it in action, it would be utterly unavailing for any useful purpose. In like manner the brain is the immediate source of emotion and thought, but without the organs of nutrition to sustain it in life and activity, it would speedily become an inert and useless encumbrance.

This dependence of the nervous system on nutrition is capable of direct proof. The medulla oblongata, which, as we have seen (pp. 113, 160), is the nervous centre of respiration, receives its supply of blood through the vertebral arteries. When these are compressed, as was done by Sir Astley Cooper in his experiments on rabbits, respiration is almost instantaneously suspended: but, on removal of the pressure, if not too long continued, the animal makes a convulsive inspiration, and gradually recovers.

In accordance with this special difference of purpose, these two groups of functions are appropriately enough termed the *animal* and the *organic* functions; because, while sensation, emotion, and thought, are peculiar to animals, nutrition and life are common to both animals and vegetables—whence, indeed, the latter are also not unfrequently termed the *vegetative* functions. So very distinct are they in nature, that even in man the organic functions may continue after all thought and consciousness are destroyed.

From this general analysis, the reader will now be aware that the human body includes the following distinct groups of organs, each charged with its own special functions:—*1st*, the great nervous centres, *i.e.* the brain and spinal cord; *2dly*, the organs of the five senses, including the peripheral expansion of the nervous system, by means of which all external impressions are received; *3dly*, the apparatus of motion for executing the behests of the mind; and *4thly*, the organs for the nutrition of the body, namely, those of digestion, circulation, and respiration. The first three constitute the organs of the animal functions, the fourth (together with the reproductive apparatus) those of the organic or vegetative functions; and this division is, so far, appropriate, inasmuch as the vegetative functions are carried on independently of the will, and in a great measure without our consciousness. But it must not thence be inferred that they are independent of nervous influence; on the contrary, we shall see as we proceed, that every function of the body is more or less under its control.

The nervous system is extremely complex, both in structure and function; but it may be described in a general way as central masses and peripheral expansions of nervous matter, linked together by connecting cords called nerves.

The principal nervous centres are the *brain* and *spinal cord*, which are frequently described under the common title of *the cerebro-spinal axis*. But both the brain and spinal cord are compound organs, consisting of congeries of ganglia, or foci for the generation of distinct nervous influences, each of which is charged with its own particular functions. Thus, the brain is the organ of the various intellectual and emotional faculties, and of consciousness and volition; while the spinal cord is the organ of the automatic functions which do not require consciousness or volition, and also the instrument by which the mandates of the will are transmitted to the muscles.

On examining a section of any nervous centre we find it to be composed of two distinct kinds of nervous matter, which, from their appearance, are generally described as the *grey* and the *white substances*. Under the microscope the former is seen to consist principally of minute vesicular or cellular bodies, and the latter of fine tubules or fibres; and hence, in the language of modern physiology, they are commonly designated the *vesicular* or *cellular*, and the *fibrous*, *nervous substances*.

These two substances are subservient to very different purposes—the former being the *generator*, the latter the *conductor* of the nervous influence. The cellular matter is the characteristic feature of a nervous centre; wherever it is found, there nervous force originates—and the amount of force developed is commensurate with the quantity of cellular matter. The fibrous or white matter links the various scattered masses of grey cellular matter together, brings them into intimate communication with each other, and forms with them those wonderful complex organs, the brain and spinal cord. We see, then, that cellular matter is the source of all nervous power; but physiologists have not yet attained the remotest idea on what it depends that different varieties of nervous power issue from different collections of cellular matter; how it is, for example, that intellectual power is connected with the cellular matter of the anterior lobe of the brain, and respiratory power with that of the medulla oblongata.

The recent investigations of Professor Kölliker of Würzburg, however, by shewing that the nervous cells differ in different parts of the nervous centres, seem to throw a gleam of light even upon this obscure department of physiology, and to point the way to a new epoch in the history of our knowledge of the nervous system.* If, with improved methods of investigation, physiologists shall discover that one kind of cell is characteristic of a centre of motion, and another kind of a centre of sensation—that one kind occurs invariably in the anterior lobes, and another in the posterior lobes of the brain—we shall obviously obtain a new power, which will not only establish on a firm basis the knowledge already possessed, but probably lead to discoveries which hitherto have hardly been hoped for.

In addition to the great nervous centres, or brain and spinal cord, we find a number of small nervous centres in different parts of the body, but principally in the thorax and abdomen. These bodies, called *the ganglia of the sympathetic system*, are about the size of peas or beans, and are generally supposed to be connected with the functions of nutrition. We shall return to their consideration in a subsequent chapter, and in the mean time confine our attention to the nervous centres which compose the brain and spinal cord.

It has already been observed that the existing knowledge of the nervous system is very far from being complete. The nervous system is known to be composed of a congeries of distinct ganglia, each having its peculiar function; but, as just mentioned, we are as yet totally ignorant on what variety of structure this difference of function depends. Nor, with the exception perhaps of the nervous centre of respiration, can we mark the limits of any particular ganglion, or shew that certain functions are strictly confined to certain portions of nervous substance. Accordingly, great uncertainty still prevails as to the functions of certain parts of the brain. But it would be entirely foreign to our present purpose to enter upon a discussion of the various theories that have from time to time been brought forward respecting them, and indeed we could not do so without premising a variety of anatomical and physiological details, which would perplex rather than instruct the general reader. At the same time, it is highly desirable that some notion should be formed of the wonderful mechanism of the great centres of the nervous system,—structures which appear more and more wonderful the longer they are contemplated. Indeed no study is capable of conveying a higher idea of the surpassing wisdom of the Creator. Of all the other functions of the body we shall possibly, in the course of time, acquire a thorough comprehension. We can, without any great stretch of imagination, follow the conversion of the food into the tissues of the body, and conceive the transformation of these again into the various excretions. We can form a plausible theory of the origin of the animal heat, and of the use of the perspiration in regulating it; but we become lost in wonder when attempting to penetrate the mysteries of the functions of the nervous system. We cannot conceive, even in the remotest manner, in what way the brain—a compound of water, albumen, fat, and phosphate salts—operates in the generating of thought, accumulating of knowledge, and storing of it up as in a granary to be produced again at will, perhaps scores of years after the time of its acquisition. How is it that a slight degree of pressure on this organ can in a moment obliterate the slowly acquired knowledge of a lifetime, and straightway convert the man of mighty genius into a drivelling idiot? We cannot tell; we simply know the fact, and bow in humility and adoration before the great Being, by whom we have been so wonderfully and fearfully made. Observation and experience teach us that on the brain depends our power to think and will—to hear, to see, to taste, to smell—in short, our consciousness; and that without it no conscious existence is ever found. It is the organ of the mind—the endowment by which we are raised to the position of moral, intellectual, and responsible beings.

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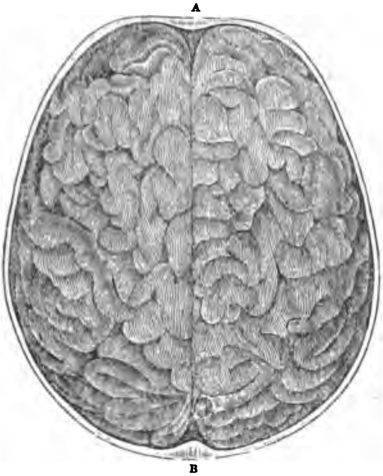
* Mikroskopische Anatomie. Leipzig, 1850.

Such, then, being the important functions of the brain, it becomes a matter of the most vital importance to the corporeal and mental wellbeing of man, that this instrument should be preserved in the highest state of efficiency and health; which can be accomplished only through strict observance of those physiological laws to which his body has been subjected. For this purpose some general knowledge of the anatomy and physiology of the great nervous centres will prove highly useful; and this we shall now endeavour to give—avoiding, for the reasons already stated, as much as possible all technical details.

The BRAIN, in the widest signification of the word, is that large organised mass which, along with its enveloping membranes, completely fills the cavity of the skull. Its structure is so complicated that less is known of it than of that of almost any other organ, as hitherto it has baffled the skill and perseverance of our most patient investigators. The cause of this ignorance is partly the minuteness of the differences which give distinct functions to different nervous regions, and partly the peculiar nature of the nervous force. Thus, while the liver, the kidneys, and the various other glands, secrete material products which are palpable to our senses, and capable of being submitted to physical tests, thereby giving us certain evident data for the comparison of their structure with their functions, we are left totally without such assistance in the study of the brain. The mental operations are imperceptible; we have no means of *physically* recognising their existence—and hence we cannot bring structure and function into the same juxtaposition as where the product is sensible. It would therefore be entirely out of place to attempt to describe the brain here, farther than by stating generally its principal divisions. On sawing off the upper half of the skull horizontally, and removing the firm tough membrane called the *dura mater*, which adheres closely to its inner or concave surface, the *cerebrum* or *brain proper* presents itself, marked on the surface with a great variety of undulating windings or *convolutions*, and extending from the fore to the back part of the head, somewhat in the form of an ellipse. In fig. 17, the convolutions are represented as seen on the upper surface of the brain.

In the middle line from A to B, there is a deep cleft separating the brain, in its whole length, into two halves or *hemispheres*. Into this cleft dips a tight stiff membrane, resembling a scythe in shape, and hence called the *falx* (scythe), or sometimes, from its being a mere fold of the *dura mater*, the *falciform* (*scythe-like*) *process* of the *dura mater*. From its dipping down between the two halves of the brain, the chief purpose of this membrane seems to be, to relieve the one side from the pressure of the other, when the head is reclining to either side.

Fig. 17.



Each half or *hemisphere* of the brain is, in its turn, divided into three portions, called, from their situations, the *anterior*, *middle*, and *posterior lobes*, each occupying nearly a third of the whole length of the brain. These divisions are manifest only on the under surface of the brain, and in fig. 18 they are pointed out by the lines E E and F F. In their natural situation, the anterior lobe, lying above the dotted line E E, occupies the forehead; the middle lobe, or that portion lying between the two transverse lines E E and F F, is situated above and a little in front of the ears; and the posterior lobe, lying below the transverse line F F, corresponds to the back part of the head.

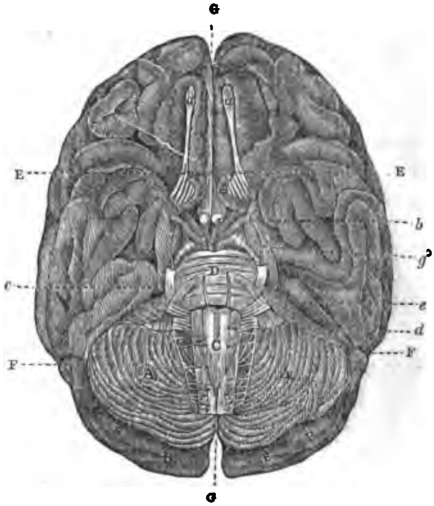
Beneath the posterior lobe, a strong fold of the dura mater, called the *tentorium*, is extended horizontally to support it and separate it from the *cerebellum* or little brain A A, lying below it, which forms the second great division of the contents of the skull. The surface of the cerebellum is marked by convolutions, differing, however, in size and appearance from those observed in the cerebrum.

Adhering to the surface of the convolutions, and consequently dipping down into and lining the *sulci* or furrows between them, another membrane of a finer texture and greater vascularity, called the *pia mater*, is found. The blood-vessels going to the brain branch out so extensively on the pia mater, that, when a little inflamed, it seems to constitute a perfect vascular net-work. This minute subdivision is probably of use in preventing the blood from being impelled with too great force against the delicate tissue of the organ.

A third covering, called the *arachnoid* membrane, from its fineness resembling that of a spider's web, is interposed between the other two, and is frequently the seat of disease.

On examining the convolutions in different brains, they are found to vary a good deal in number, size, depth, and general appearance. In the various regions of the same brain they are also different, but preserve the same general aspect. Thus, they are always small and numerous in the anterior lobe, larger and deeper in the middle, and still larger in the posterior. The depth to which they penetrate may be judged of from their appearance in fig. 19, representing a vertical section of the brain.

Fig. 18.

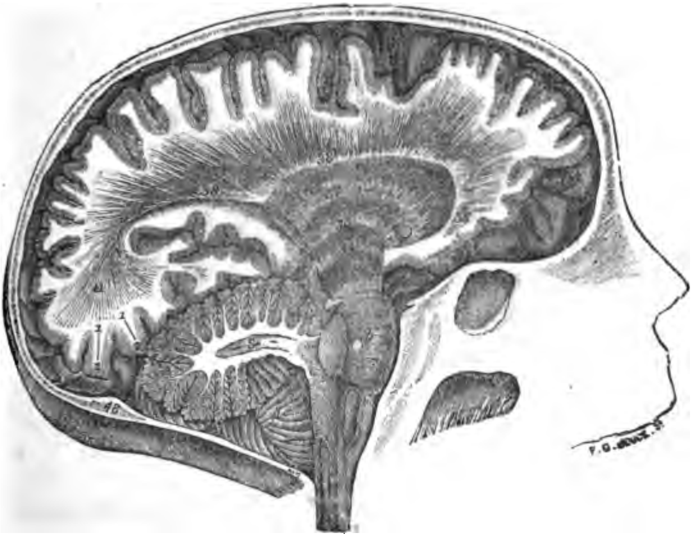


But besides the cerebrum and cerebellum certain other nervous structures are contained in the skull, and form part of what is generally denominated the brain. These are, first, the *medulla oblongata* (fig. 18, C; and fig. 19, *e e c*), which is the name bestowed upon the upper portion of the spinal cord, and which extends upwards from the point where it enters the cranium (fig. 19, 47), till it passes into the crura of the cerebrum (*g*), being latterly covered by the *Pons Varolii* or *mesocephale* (fig. 18, D, and fig. 19, *b*), which, as we shall presently see, may be reckoned as part of the cerebellum. Between the crura of the cerebrum, which may be reckoned as the continuation of the medulla oblongata, and the cerebrum itself, lie various ganglionic bodies containing both cellular and fibrous matter (fig. 19, 34, 35, 37), the principal of which are the *corpora quadrigemina*, the *optic thalami*, and the *striated bodies*. These various structures, besides serving as the means of communication between the cerebrum and spinal cord, are themselves independent nervous centres from which emanate peculiar nervous powers, and which, for the sake of simplicity, we shall comprehend under the common term of the *Cephalic Ganglia*.

The remaining part of the nervous centres is the *spinal cord*, which is the continuation of the medulla oblongata downwards, and the means of communication between the brain and most of the nerves of the body.

These various divisions of the nervous system pass gradually into each other, and in the adult present no well-defined line of demarcation. In some of the lower animals, however, and in the human embryo, the limits of each division are more clearly marked; and as it is of importance that their mutual relations should be well understood, we have endeavoured, in the following diagram (fig. 20), to give a general idea of their relative position and extent.

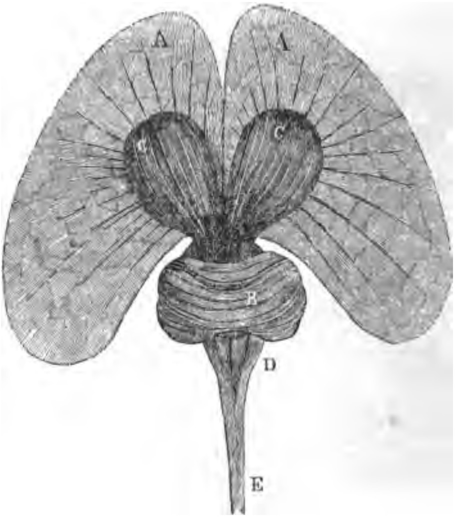
Fig. 19.



In that diagram, E marks the posterior superior portion of the spinal cord, which gradually increasing in thickness, passes insensibly into the medulla oblongata D, which may be described as a continuation of the spinal cord with more complicated functions. It extends under the cerebellum B, to be continued into the cephalic ganglia C, and in its course is intimately connected with the fibres of the pons Varolii, which is here hidden by the cerebellum. The pons Varolii and cerebellum may be rudely compared to a ring—the cerebellum representing the stone, and the pons the hoop; while the medulla oblongata may be likened to the finger. Before entering the ring, however, the medulla oblongata gives off numerous fibres which communicate with the cerebellum (fig. 19, *e*), and in its passage through the ring its longitudinal fibres and the transverse fibres of the pons, enter into the most intimate connection.

The *hemispheres* A A (fig. 20) are supposed to be partially removed, and are represented as separated from each other and turned outwards so as to shew the deeper-lying structures. As here seen, the hemispheres constitute by far the largest of these divisions; but such is not the case in the earliest stages of foetal development, where the spinal cord, medulla oblongata, and cephalic ganglia, are first formed. The cerebrum and cerebellum are later formations gradually sprouting out from the cephalic ganglia and medulla oblongata. On their first appearance the hemispheres consist of small bags of nervous matter filled with water, which is gradually absorbed, and its place occupied by additional nervous matter, which is deposited as development proceeds. It sometimes happens, however, that the development of the brain is arrested, and that infants, in other respects perfect, are born without the cerebrum and cerebellum. This fact is of physiological importance, since it shews that the nutrition of the body is not directly connected with the presence of these organs; and, as such infants cry lustily, and readily take the breast, it shews moreover that these actions must be dependent on some other part of the nervous centres.* The convolutions on the surface of the cerebrum do not exist in the first months of development; they are gradually formed as the water is absorbed, but in certain diseased states, as that of chronic hydrocephalus, where the head occasionally acquires an enormous size, the nervous bags continue distended, and no convolutions are formed. The convolutions seem therefore to be a provision for increasing the surface of the vesicular layer or gray matter, without a corresponding increase of the size of the cranium. The *ventricles* or cavities which exist in the normal adult brain, are the remains of the embryonic nervous sacs.

Fig. 20.



Considered as a whole, the nervous system falls, as we have said, into two great divisions—that of animal and conscious life, and that of organic and automatic life. The latter constitutes the mechanism which, so far as it can be safely allowed, is under the control or command of the former.

In fig. 21, which represents a vertical section of the brain, it will be remarked that all the nerves issue from the cephalic ganglia C, the medulla oblongata D, or the spinal cord E. They have no immediate connection with the cerebrum A, or the cerebellum B, which, as has been observed in describing the development of the brain, may be regarded as adjuncts to the rest of the nervous system. The cephalic ganglia, medulla oblongata, and spinal cord, constitute therefore *the automatic part of the nervous system* which presides over the organic functions by means of the nervous power generated in it, independently of the cerebrum and cerebellum. In the automatic brain, then, (under which designation we shall, for the sake of brevity, include the cephalic ganglia, the medulla oblongata, and the spinal cord), are the terminations of all the nerves. Accordingly, here it is that stimuli applied to the peripheral extremities of the nerves are converted into *sensations,* though without the cerebrum these sensations cannot become *perceptions.** Sensations differ in nature according to the functions of the automatic centre in which the nerve conveying the impression terminates. For example, an external stimulus applied to a spinal nerve produces a change in some particular part of the spinal cord, which is recognised by the brain as a "common sensation;" and a stimulus applied to the optic or auditory nerve acts on its special centre, producing changes which the brain recognises as sight or hearing. Thus every part of the automatic centre has its own peculiar functions, which, in the spinal cord, are limited to sensation and motion, but which become much more complicated in the far more complicated structures of the me-

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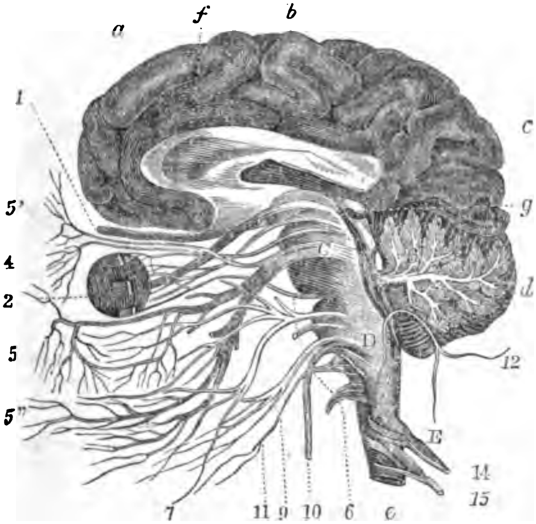
* For details of such cases, see Memoirs of the Nervous System, by Dr Marshall Hall, p. 16. London, 1837.

Fig. 21.



a, the anterior lobe of the cerebrum; *b*, the middle lobe; *c*, the posterior lobe; *f*, section of the corpus callosum, which joins the two hemispheres. Underneath this transverse layer of nervous matter lie the ventricles of the brain, and portions of the cephalic ganglia which are overlapped and partly concealed by the cerebrum.

1, Olfactory nerves; 2, the eye and optic nerve; 3–12, the remaining *cerebral* nerves, so called from their origin within the cranium; 14, 15, the first two spinal nerves.

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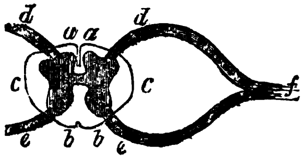
* We here use the term *sensation* to signify the mechanical response by the automatic brain to a change in the molecular condition of the sensory nerves. The recognition of this change by the cerebrum implies a *consciousness* of the sensation, or *perception.* In ordinary language, the word *sensation* is frequently used to denote *perception.*

dulla oblongata and cephalic ganglia. Hence, as will afterwards be more fully shewn, it is erroneous to speak of any particular part of the automatic brain as the exclusive seat of sensation. To the continuance of life the integrity of the cerebrum and cerebellum is of far less importance than the integrity of the automatic brain; and we shall see as we proceed that the first two may be removed from an animal without the immediate destruction of life, while injury to the medulla oblongata is followed by instantaneous death from the stoppage of the process of respiration. In like manner the cerebrum and cerebellum may lose their action in sleep, whereas the sleep of the automatic brain would be synonymous with death.

In sleep, the body is confided to the watchful care of the automatic brain, and especially of the medulla oblongata and spinal cord. The former, we have seen, constitutes the nervous centre of respiration, and it is unnecessary to enter upon any formal proof that its action is persistent; for, were the fact otherwise, the stoppage of its function would speedily be followed by death. It is however not at first sight equally apparent that the *spinal cord* is in constant action; but consideration of the following facts will shew that this is really the case. When treating of the muscular system, we pointed out (p. 91) that at all times there is a flow of nervous power from the spinal cord to the muscles, which is seen in the firmness and tone imparted to them even during sleep, a state contrasting in a marked manner with the flabbiness they acquire in paralysis. Some animals, of which the horse is a familiar example, frequently sleep standing, which they could not do if a contractile stimulus did not flow from the spinal cord independently of the sleeping nervous centres. We see, moreover, that the muscle which closes the lower extremity of the intestinal canal retains its contractile power as completely during sleep as in the waking state; and observations made in disease, as well as experiments on the lower animals, prove that this power is dependent on the integrity of the spinal cord, and does not cease when voluntary muscular power is lost.

On making a transverse section of the spinal cord, it is seen to be composed of an internal gray or cellular nervous mass, and an external white or fibrous nervous substance, and thus presents the characters both of an originator and a conductor of nervous power. The fibrous white matter, which encloses the gray centre, is generally described as being composed of six columns, two anterior *a a*, two posterior *b b*, and two lateral *c c*. These various columns, however, are intimately connected together, and cannot be separated without tearing the nervous substance. The anterior columns contain exclusively motor fibres, which pass from the brain to the muscles; while the posterior columns contain exclusively sensitive fibres, passing from the different parts of the body to the brain. The lateral columns contain both motor and sensitive fibres, the former lying chiefly in their anterior, and the latter in their posterior portions; so that the spinal cord might be more simply described as consisting of *anterior motor* and *posterior sensitive* columns, meeting at the sides, and enclosing a centre of gray cellular matter, represented by the shaded central part of the figure. The division into six columns is an arbitrary one—the ideal separation of the anterior and posterior columns from the portions of the lateral columns which respectively belong to them, being marked by the passage of the nerves *d d*, *e e*.

Fig. 22.



As it is of essential importance to the proper comprehension of the difference between reflex and voluntary motion that a correct general idea should be formed of the structure of the spinal cord, we shall now endeavour to explain, but with as little detail as possible, the course of the nervous fibres to and from the brain.

Fig. 23.

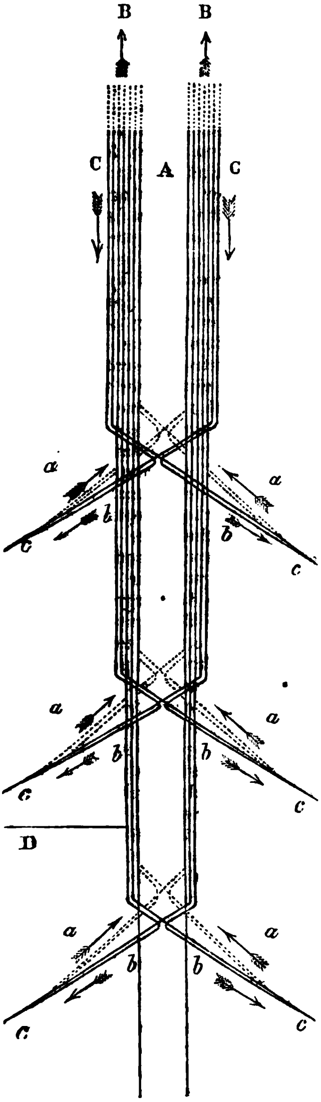


Fig. 23 is a diagram illustrating the course of the fibres of the spinal cord.

A, the gray centre.

B B (dotted lines), the sensitive columns lying behind

C C, the motor columns, cut short to shew B B.

a a a, the sensitive fibres passing from the periphery to the brain. In their course they enter the gray centre, and passing into the posterior columns continue their course to the brain.

b b b, the motor fibres, which after descending the anterior columns pass into the gray centre, and make their appearance as the anterior roots of the nerves.

c c c, the nerves composed of posterior fibres *a*, and anterior fibres *b*.

This diagram is intended to represent a thin longitudinal slice of the spinal cord, seen from before, and shewing the course of the motor fibres in the anterior columns C, and those of the sensitive fibres in the posterior columns B. On examining the diagram, it will be observed, in the first place, that each fibre is continuous from the brain to the periphery of the body, and from the periphery to the brain, and that each in its course from the periphery or from the brain enters the gray centre of the cord A, either passing entirely through it to become associated with the fibres of the opposite side, or bending upon itself to pursue its course on its original side. In this way each nerve *c*, contains fibres coming from both lateral halves of the cord.*

Inspection of the diagram will also shew that each nerve is composed of fibres coming both from the anterior columns C, and the posterior columns B. These two sets of fibres constitute the motor and sensitive roots of the nerves; *d e* in fig. 22 coalescing to form the nerve *b*. The sensitive roots are represented by the dotted lines in the diagram; they pass into the posterior columns, which lie behind the anterior columns, and pursue their way to the brain; and the mandate which follows on the impression they convey upwards is brought down by the motor fibres, represented by the continuous lines.

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* To guard against misconception, we may here remark, that the knowledge which has been attained of the structure of the spinal cord is still exceedingly imperfect. The description in the text of the crossing of the fibres (see Kölliker, op. cit.) perhaps facilitates the explanation of the power of motion which animals retain in both sides of the body after division of one of the lateral halves of the cord (see Valentine's Lehrbuch, vol. ii., part 2, p. 481); but, on the other hand, it renders more difficult the explanation of hemiplegia, or paralysis of one-half of the body.

In this course the fibres of the nerves are in connection with two sources of nervous power. A stimulus applied to the extremity of the nerves *c*, produces a change which is propagated in the first place to the gray centre of the spinal cord, and thence upwards, through the sensitive column B B, to the brain. The result which follows is dependent on the condition of the centres which are thus excited. If we suppose the spinal cord to be transversely divided at D, any stimulus applied to the nerves below this point will affect merely the spinal centre lying below the section, and the excitement thus produced will be communicated to (or *reflected* on) the motor fibres coming from this portion of the spinal cord. A pure reflex motion will thus be produced. Again, if instead of the stimulus being prevented from acting on the brain by section of the cord, it is simply not recognised by the brain owing to the action of the latter being suspended by sleep, the movements which result from irritation of the extremities of the nerves will still be reflex. This is seen when the foot is withdrawn on being tickled during sleep. If, however, the spinal cord be entire, and the brain awake, a knowledge of the changes produced by the stimulus in the spinal centre is propagated to and recognised by the cerebral centre, and we accordingly become conscious of them.* This consciousness is followed by volition, and a voluntary mandate is forthwith dispatched through the motor fibres, to call into action that particular portion of the automatic centres which is necessary to produce the required movements. In man the cerebral preponderate so much over the spinal centres that volition in general controls automatic action. But this is not invariably the case, as no voluntary effort is sufficient to enable us to resist the automatic action which follows tickling of the nostril or windpipe—that is, sneezing or coughing. In animals where the brain is little developed, reflex action preponderates, and this is seen also in man where the brain is weakened by disease, or prevented by spinal injury from exercising its controlling power. Indeed, in certain abnormal conditions, the spinal centre generates nervous power in such abundance that it loses its character of a passive instrument, and produces convulsive action of the limbs by its own spontaneous action. An example of this state is given in page 91. In its normal condition, however, with the exceptions already mentioned at the place referred to, it possesses no spontaneous action, but is simply a generator of nervous power, which is discharged according to the nature of the stimuli which the nervous fibres convey to it. If the stimulus come from the periphery, the resulting movement is reflex and involuntary; if it come from the brain, it is generally voluntary, though, as explained in page 88, not always so. In the healthy state, the effect of a peripheral stimulus is usually limited to the particular section of the spinal cord with which the afferent nerve is connected. Thus, if the hand be suddenly pricked, the stimulus is confined to the portion of the spinal cord from which the nerves of the arms issue, and the hand is snatched away. But in abnormal states the excitement of the spinal cord is not thus limited, but is radiated as it were through the whole of the gray centre, giving rise to general convulsions. The limitation of the excitement is well seen in cases of the irritation of particular nerves, such as those of the throat or nostril, when a stimulus produces vomiting or sneezing.

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* See Art. on the Nervous System by Remak in the Encycl. Wörterbuch der Med. Wissensch., vol. xxv., p. 176. Berlin, 1841.

It has been objected to the theory of the continuity of fibres from the brain to the periphery, and *vice versa*, that, were it true, the spinal cord in the region of the neck would be much thicker than it really is, as the combined area of the sections of all the nerves much surpasses the area of the section of the cord at its superior part. Kölliker, however, has met this objection by shewing that the fibres of the nerves when they enter the cord become much thinner, and he has made some very elaborate calculations to prove that the area of the cord is amply sufficient to permit the continuity of the attenuated fibres.*

But our more immediate object at present, is to investigate the nature of the *functions* of the nervous centres of animal life. To arrive at the knowledge of these, physiologists have had recourse to various methods of investigation; but all of them are so beset with difficulties, that the conclusions arrived at by different investigators are frequently in total opposition to each other. This is especially the case in matters of detail, though, in so far as the general functions of the great divisions of the brain are concerned, a certain degree of harmony prevails.

The *first* means of ascertaining the functions of the various parts of the brain, is the study of their comparative development in man and the lower animals. We have seen above that the cerebral hemispheres may be considered as in a manner adjuncts to the rest of the nervous system, since their absence does not directly interfere with the nutrition and development of the organism. Indeed, as we descend in the scale of creation, we at last reach animals where their almost total absence is the normal condition. This may be said to be the case in fishes, where the brain may be described as almost entirely consisting of central ganglia for the principal nerves, and thus constituting an automatic instrument. In other animals, again, higher in the scale, the brain seems to be arrested at some particular stage which the human brain passes through in the course of its development. The cerebrum is still present, but of very small size; and the convolutions by which the superficies of the cellular matter is elsewhere increased, do not appear at all. As a general rule, along with this arrest of development the mental faculties are found correspondingly circumscribed, and below the birds we do not recognise any intellectual manifestations bearing affinity to those of the human mind. In birds, however, we still observe the manifestations of affections and passions analogous to those of man, together with a certain amount of intellectual capacity. These mental manifestations increase in the mammalia. "It is in them," says Professor Owen, "that the progressive expansion of the brain is greatest, and the final predominance of reason over instinct is achieved. In this class, sensation is the chief characteristic rather than muscular energy or irritability; the instincts become more varied, they are also less mechanical and more educable. In Mammalia we first find the cerebral hemispheres acquiring an additional extent of the gray and vascular surface by convolutions, which increase in number and depth as the species approximate man."* From such facts we infer the connection of the hemispheric lobes with mental manifestations; although such observations are far from yielding unassailable evidence, that certain parts of the brain are in all animals invariably connected with the manifestation of certain faculties. We cannot as yet maintain that, throughout the animal kingdom, in the absence of such and such a part of the brain, such and such a faculty must be wanting. On the contrary, our present knowledge seems rather to indicate that Nature may, and often does, in animals of different species, attain the same ends by the use of different means. In no other way can we explain the occasional existence of certain functions in the lower animals, in which that portion of the brain with which they seem in man to be connected, is not developed.

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* Mikroskopische Anatomie, vol. ii., p. 435. It is a matter of little practical importance whether we adopt the theory of the continuity of the nervous fibres from the periphery to the brain, or believe, with Volkmann, that the nerves terminate in the spinal cord, but are connected with the brain by means of *spinal* fibres, one of which may suffice to convey the stimulus brought from the surface by several *nerve* fibres. In this way he explains the comparatively small size of the spinal cord in the region of the neck. See his article on Nervenphysiologie in Wagner's Handwörterbuch, vol. ii.

* Lectures on the Comparative Anatomy of the Vertebrate Animals, vol. i., p. 19.

The *second* means of determining the functions of the brain is the making of experiments on living animals. But here great discrimination is necessary to avoid mistaking the results caused by the general shock to the system, for those specially due to some particular lesion of the nervous centre. It is in a great measure owing to this source of error, that different experimenters have arrived at such contradictory conclusions.

In the phenomena which accompany disease, we have a *third* source of information regarding the uses of the nervous system; but one also extremely liable to misconception, first, from the difficulty of deciding that the disease is strictly limited to certain portions of the nervous substance, and, secondly, from the fact that the brain, like the eyes and ears, is double, so that the healthy action of one hemisphere may conceal the effects of disease in the other.

Further, we have in chloroform and other anæsthetic agents a means of analysing the action of the various great divisions of the nervous system: for with their aid it is possible to suspend the action of certain portions, while others remain unaffected.

Finally, by comparing the size and external form of the cranium (as pretty accurately indicative of the size and form of the inclosed brain) with the mental manifestations, we ascertain that certain cerebral parts are connected with certain emotional and intellectual faculties.

It is more than probable that improved methods of preparing the nervous substance for microscopic investigation, will bring great additions to our knowledge. In the mean time, the researches of Kölliker and other investigators are gradually preparing the way.

From the knowledge furnished by these various sources, physiologists are now universally of opinion that the cerebrum, or hemispheric lobes of the brain, constitutes or includes the organ of the intellectual and moral powers. It is the seat of consciousness, volition, and emotion, and when it is removed the body sinks into a mere machine, which acts in obedience to the inherent forces of the automatic brain, or responds to physical stimuli according to the laws of reflex action. In the lower animals, for instance, when deprived of the hemispheric lobes, the movements are purely automatic, although still evidently adapted to the attainment of a purpose. Misconception on this head, has induced many physiologists to believe that consciousness is not confined to the cerebrum, but is a general attribute of the whole cerebro-spinal axis. But it is clear that the acephalic infant which takes the breast, does so purely as an automaton, and not from consciousness.* In a former chapter (p. 91), we had occasion to mention the experiment of Flourens, in which a pigeon, after being deprived of the cerebrum, continued to live for several months. But the animal was a mere living automaton. It swallowed when grain was put into its mouth, ran when it was pushed, and flew when it was thrown into the air; but when left alone remained passive as if sunk in a profound sleep. There remained the cerebellum, the cephalic ganglia, the medulla oblongata, and the spinal cord; consequently the whole apparatus of sensation and motion: but the organ through which *sensation* becomes *perception*, and through which voluntary power is exercised, had been removed. We are told by Flourens that the animal was not aware of obstacles in its way, but flew or ran against them. This, however, might have been otherwise; for (as fig. 21 illustrates), although the hemispheres of the brain be removed, the animal will, nevertheless, retain the eye which receives the light, and the cephalic ganglia where its stimulus becomes converted into sight. Theoretically, therefore, the animal ought to have had the sensation of light, though destitute of the consciousness of sight; and the absence of that sensation was probably due to the derangement of the functions of the cephalic ganglia by the shock of the operation. In analogous experiments by other investigators, there is ample evidence that sight was *not* destroyed. For instance, a frog, which Volkmann had deprived of the cerebral lobes, when placed in an earthenware vessel sprang towards the light, and not forwards against the walls of the vessel, which would have been its natural action had it not felt the sensation of light.* According to Longet, the pupil of the eye of a pigeon which has been deprived of the cerebral lobes, contracts on the approach of a light, and the head turns mechanically to follow it. When a pistol is fired near the bird, it opens its eyes and stretches its neck, but again subsides immediately into its slumber.

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* See Dr Marshall Hall, *loc. cit.*

In these examples, we have automatic motion springing from the inborn action of a nervous centre, or caused by the impression produced by external stimuli. The frog leaping upwards, and the pigeon following with its head the movements of the light, acted without consciousness or volition, but in obedience to the dictates of the automatic brain. We can explain the movements of respiration in no way more satisfactorily than by supposing them to originate in the inborn power of the medulla oblongata; and we may analogically suppose the automatic motions of animals which have been deprived of the cerebral lobes, to spring in like manner from the direct action of those parts of the nervous centre, which for simplicity we have classed together under the general term of the automatic brain. Or, to a certain extent, they may be explained as the result of reflex action. For instance, the stimulus of light, when conveyed to the cephalic ganglia, produces a change which is reflected as motor power on the motiferous nerves, and thus produces certain automatic movements. A case illustrative of this fact is given below.

But all parts of the automatic brain are not of equal importance. The cephalic ganglia and medulla oblongata are much more complex in structure, and preside over a greater variety of functions, than the spinal cord. Experiments on animals clearly shew that the two former possess spontaneous powers of action. An animal which has been deprived of the cerebrum and cerebellum still moves its limbs automatically, though it is incapable of voluntary motion; and one which retains the medulla oblongata uninjured, still breathes, though the whole of the rest of the cerebro-spinal axis has been removed. But it remains doubtful whether the spinal cord possesses the power of spontaneous action. The fact of animals running and of birds flying short distances after sudden decapitation has been reported by several authors; but Volkmann, in numerous experiments, was never able to see this phenomenon. The spinal cord, however, undoubtedly retains its power of responding to stimuli, whether applied directly to its substance at the point of division, or indirectly to the extremities of the peripheral nerves. The following extract, taken from the pages of a non-medical but scientific writer, will shew that it is from the spinal cord that the muscles immediately derive their contractile stimulus, and that the *mechanism* of motion is independent of the cerebrum.

"A young alligator was decapitated

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* Wagner's Handwörterbuch der Physiologie, vol. i., p. 580.

at the point where the neck or atlas articulates with the occiput. Not more than two ounces of blood flowed from the wound. The jaws of the detached head still snapped at anything which touched the tongue or lining membrane of the mouth.* After the convulsions produced by decapitation had subsided, the trunk of the animal remained in a state of torpor resembling profound sleep. But when pinched or pricked on the sides, the creature would scratch the spot, sometimes with the fore, and sometimes with the hind-foot, according to the situation of the injury inflicted. These movements of the limbs were promptly and determinately performed, and were always confined to the members on the side of the irritating cause. If touched below the posterior extremity on the thick portion of the tail, he would slowly and deliberately draw up the hind-foot, and scratch the part, and would use considerable force in pushing aside the offending object. These experiments were repeatedly performed, and always with the same result."† They were made by Dr Le Conte; and Sir Charles Lyell refers to the *New York Journal of Medicine*, Nov. 1845, for more ample details.

Here the mechanical irritation of the peripheral extremities of the nerves produced in them a molecular change which was propagated to the gray matter of the spinal cord, and there reflected on the motor nerves according to the natural laws of action of the spinal nervous centre. For this purpose no effort of the will was necessary. In the unmutilated animal consciousness would doubtless accompany the movements, but the absence of consciousness does not interfere with their execution. There can be no will without consciousness; and that neither the one nor the other exists in a decapitated animal is proved by its remaining quiescent after the first convulsive motions have subsided, so long as no stimulus is applied to it.* We all know from our own experience that if the hand be suddenly pricked it is withdrawn by an involuntary action, and that if a liquid enter the windpipe we have an involuntary fit of coughing. These involuntary actions depend on the gray centre of the spinal cord, and would equally take place were the brain removed, if this operation could be performed in man without instantly destroying life. They are seen every day in cases of apoplexy, where all consciousness is destroyed by disease, and where, accordingly, there is no perception of sensation. When the skin of the decapitated alligator was pricked, the same change was produced in the nerves of sensation as if the animal had been unmutilated; and this change was propagated to the spinal cord, and there reflected, according to precisely the same laws which regulate the spinal cord of an unmutilated animal. But no change was recognised by the brain, for the simple reason that the brain no longer formed a part of the body. Consequently there was no consciousness of the irritation, for this depends on changes which must be propagated to the brain to cause *perception*. The surgeon's knife produces the same changes upon the nerves of a person under the influence of chloroform, as upon the nerves of one who is free from its influence. These changes are propagated to the nervous centre of sensation, and are recognised by the automatic brain—of which fact we have evidence in the unconscious moaning which frequently accompanies the incision; but the anæsthetic agent has produced in the cerebrum a molecular change, which, for the time, alters its action and prevents its perceiving the pain. If the use of the chloroform be pushed too far, the automatic nervous centres also are affected; the tonic contraction of the muscles is destroyed, the sphincters relax, respiration ceases, and death ensues.

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* This action was due to that part of the spinal centre which remained in the cranium.

† Lyell's Second Visit to the United States, vol. i., p. 317.

* When a decapitated frog is extended on the table, it draws up its extremities and assumes its usual sitting posture. But Valentin has shewn that this is probably a purely physical result, depending on the greater power of the flexor muscles over the extensors. The tonic action of the former prevailing, draws up the limbs.

For these reasons, then, we consider the spinal cord as in a great measure *a passive instrument*, and incapable of spontaneous action beyond that which gives the tonic muscular power already mentioned. But it is ready to act in obedience to stimuli reaching it from the brain or from the peripheral nervous expansion.

For this purpose, however, the spinal cord must be in unbroken communication with the brain and peripheral nerves; for when the channels by which stimuli reach it are destroyed, or altered in their molecular constitution, it necessarily loses the property of responding to them. Accordingly, in diseases of the cord the operation of the will cannot be extended to portions below the seat of the injury, and hence the muscles supplied by such portions remain paralysed; or if, on the other hand, the nerves leading from the periphery to the cord be cut, no external stimulus can reach it, and consequently no reflex motions can be produced. Thus, if the nerve which supplies the nostril be cut, no amount of irritation will produce sneezing. When treating of the muscles (p. 90), we stated that there is reason to think that the spinal cord is not a single organ, but that it is composed of *a congeries of nervous centres*, each having its own particular sphere of influence. The experiments which support this view have been made chiefly on such of the lower animals as are extremely retentive of life; but they may be applied analogically to man, and several facts in human anatomy and physiology render this supposition extremely probable. Wherever, for example, much nervous power is required, we find the gray matter of the spinal cord increased in thickness. This is particularly the case at the origin of the nerves which supply the upper and lower extremities—an unnecessary provision if the nervous power be supposed to flow from the spinal cord as from *a single organ*. Again, when that portion of the cord is destroyed from which the nerves of the inferior extremities are derived, paralysis of the latter is produced, while the upper extremities retain their power of motion as if the cord were entire; and though it be true that paralysis of the upper extremities, produced by injury of that part of the cord from which *their* nerves proceed, extends also to the lower extremities, this happens simply because the destruction of the upper part of the spinal cord renders impossible the downward transmission of a contractile mandate. In this case, however, the inferior extremities exhibit reflex motions on *irritation of their peripheral nerves*, thus clearly indicating the existence of a nervous centre below the seat of the injury. But if the disease of the upper portion of the cord be limited to the gray centre, which is the source of the spinal nervous power, so that the conducting function of the columns of white matter remains unimpaired, a voluntary stimulus may still be transmitted from the brain to the inferior and healthy portion of the cord, giving rise to the rare phenomenon of paralysis of the upper extremities, with perfect use of the lower. A case of this kind is quoted by Dr Abercrombie from Ollivier.* In reptiles, which are very retentive of life, the amputated tail writhes and twists when it is irritated, the muscles deriving their contractile stimulus from the portion of spinal cord contained in the tail. This is readily proved by destroying the spinal cord, for then all power of motion on irritation is lost. In insects, analogous phenomena are exhibited even in a more surprising degree: "The jaws of the separated head of the mantis bite forcibly the stick which is held to them. The formidably armed prehensile legs in like manner wound the finger that touches them, when the segment of the body supporting them is separated from the head and the rest of the trunk. And if the decapitation or amputation of the pro-thorax be neatly performed on the living insect, while in its natural and ordinary position, perched by the middle and hinder legs upon a twig, the rest of the trunk does not fall to the ground, but is maintained for a certain period in that posture, which it even recovers by action of the wings, when the balance is slightly and purposely disturbed."*

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* Pathological and Practical Researches on Diseases of the Brain and Spinal Cord, p. 348. Edin. 1828.

In the cephalic ganglia are the ultimate terminations of the sensory and motory nerves, which accordingly do not pass into the hemispheric lobes, but merely present an instrument on which the cerebrum may impress its mandates, and from which it may receive a knowledge of the sensations produced in the different automatic centres.

In the opinion of many physiologists, the CEREBELLUM is the organ through which we exercise voluntary control over the muscles. Its removal does not altogether destroy motion; but the animal seems incapable of directing its body by the will. Thus, when the cerebellum is removed, but the rest of the nervous centres are left, the animal recognises and endeavours to avoid any threatening danger, but it can no longer command the use of its limbs, and strives in vain to move. Nightmare seems to present a somewhat analogous condition. In this state there is a strong but fruitless struggle to change the position or to escape from supposed danger; and the inability to move is probably due to suspension of the action of the cerebellum by sleep. It has before been pointed out that, in willing any particular movement, we have no consciousness of the way in which the particular muscles are called into action; but simply will the motion and it takes place. (See p. 90.) Kölliker conjectures that it is the function of the cerebellum to direct the motor influence upon particular nervous fibres, so as to produce the required movements. According to this theory, the cerebellum is not the source of voluntary motor power, which, as we have already seen, originates in the gray matter of the various portions of the automatic brain, but simply the director of voluntary motor power. The cerebrum informs it what motion is to be performed, and the cerebellum selects the proper fibres along which to despatch the mandate to the gray matter of the cord.

The fibres of the automatic brain do not pass into the cerebellum, which, like the cerebrum, may be cut without producing either motion or pain, while the slightest irritation of the fibres of the medulla oblongata is followed either by convulsions or the acutest agony, according as the motor or sensitive fibres are injured. Both the cerebrum and cerebellum are parts superimposed upon the automatic brain —they are the directors of the mechanism.

When the cerebellum is injured, the power of locomotion is, at least in many cases, injured likewise; but paralysis must not on this account be considered as necessarily implying disease of the cerebellum. The causes of paralysis are manifold, and great judgment on the part of the practitioner is frequently necessary to discriminate between them. It may arise, in the first place, from local disease of the *nerves*, impeding the transmission of the contractile stimulus from the spinal cord to the muscles. Secondly, it may be due to disease of the *spinal cord* itself, which refuses to act in obedience to the mandate of the will. Thirdly, it may be caused by disease of the *cerebellum*, whereby the power of stimulating the spinal cord to action is lost. Fourthly, the complicated structure of the *cephalic ganglia* may be injured, whereby the connection between the seat of volition and the automatic brain may be destroyed, or the communication between the cerebrum and cerebellum broken down, so that the command of the former is no longer conveyed to the latter. And, lastly, the *cerebrum* itself may be diseased, and therefore no voluntary mandate be generated.

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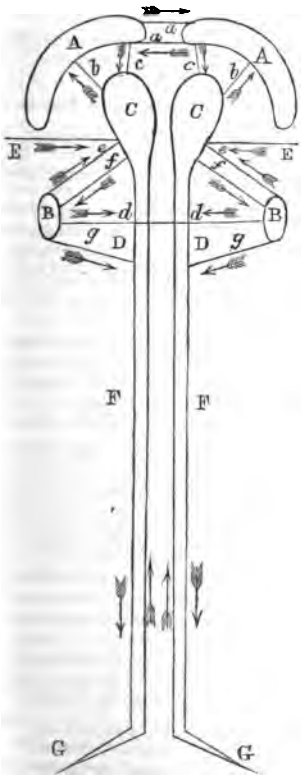
* Owen's Lectures on the Invertebrate Animals, p. 107.

When one half of the cerebellum is removed, the animal is seized with an uncontrollable impulse to revolve on its axis, turning sometimes sixty times in a minute; and this motion occasionally continues for days. It seems to be caused by the preponderating stimulus which the muscles of one side of the body derive from the half of the cerebellum which is left: when the remaining half is removed the stimulus is equalised, and the revolving motion ceases. Another phenomenon is observed when the communication of one of the hemispheres of the cerebrum with the cerebellum is cut. Here the animal, instead of revolving on its axis, runs round and round in a circle like a horse in an amphitheatre, probably because unequal amounts of stimulus are received by the cerebellum from the two halves of the cerebrum.

In the accompanying diagram (fig. 24) we have endeavoured to give a general, though necessarily very imperfect idea, of the connection of the various nervous centres, and of the course of the fibres from the periphery to the brain, and from the brain to the periphery. In doing so we have avoided all attempt to shew the mutual communication of the two sides of the nervous system in the cephalic ganglia, medulla oblongata, and spinal cord, as it would be quite impossible to give any just idea of it.[*]

Fig. 24.



A, A, The hemispheres of the cerebrum united together by the fibres *a*, *a*, and connected with the cephalic ganglia C, C, by means of the fibres *b*, *b*, *c*, *c*.

B, B, The two halves of the cerebellum communicating with the motor fibres in the medulla oblongata D, by means of the fibres *g*, *g*, which Kölliker[†] thinks are in themselves neither motory nor sensitive, but serve the purpose of communicating the voluntary motor impulse to the motor fibres of the medulla. They also, perhaps, convey to the cerebellum a knowledge of the state of the muscles. *d*, *d*, the transverse fibres of the pons Varolii, which form the communication between the two halves of the cerebellum, and probably, also, assist in imparting the voluntary motor stimulus to the medullary fibres. *e*, *f*, communicating fibres between the cerebellum and cephalic ganglia, and through these with the cerebrum.

E, E, The nerves of the special senses proceeding to the cephalic ganglia.

F, F, The spinal cord, each half shewing a motor fibre proceeding to the periphery, and a sensitive fibre proceeding to the brain.

G, G, Two spinal nerves, each containing a sensitive and motor fibre.

It is proper to observe that the prevalent opinion respecting the connection of the cerebellum with voluntary motor power rests, in a great measure, upon experiments performed on living animals. But as these must of necessity be attended by the lesion of other structures, capable, possibly, of giving rise to the phenomena from which the inference is drawn, we cannot, in the present state of our knowledge, implicitly rely upon the results so obtained. To a certain extent the theory is supported by observations made in disease; but neither can we regard this source of information as by any means conclusive, since cases of cerebellar disease occasionally occur, unaccompanied by impairment of the motor functions. Finally, the observations of comparative anatomists, though likewise tending to give the theory support, cannot be received as decisive evidence concerning the functions of the cerebellum in man.*

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[*] On this head, and on the course of the nervous fibres generally, the reader will find much information in the admirable work of Professor Kölliker on Microscopical Anatomy.

[†] Mikroskopische Anatomie, vol. ii., p. 464.

But whatever may be ultimately established in regard to this matter, it appears certain that at least a portion of the cerebellum is the organ of the sexual propensity. Numerous observations in man and the mammalia have placed this function beyond all reasonable doubt; but the question, what parts of the cerebellum are appropriated to it, or in what manner the motor and amative functions may be supposed to co-exist in the whole organ as modifications of one fundamental power, remains to be solved by future investigators. For information on the latter function, we refer to the volumes mentioned below.†

We shall now endeavour to make a practical application of this rapid survey of the nervous system, as a guide to the explanation of the nervous phenomena presented by the human mind. The reader is probably convinced by what has been said, that the brain cannot be truly regarded as a single organ, but is composed of various parts, each exercising its own independent function. Thus, we have seen that the presence of the cerebrum is not necessary for the production of the sensation of light, although it is required to produce conscious sight. The frog leaps upwards, guided by the impression produced on its cephalic ganglia, but it had nevertheless no consciousness of seeing. In somnambulism an approach to a similar condition is observed. The cerebellum and automatic brain are awake, while the cerebrum is asleep; and the somnambulist is guided in a state of unconsciousness over the most dangerous paths by the impression of the light upon the cephalic ganglia.* But there is this difference, that in the sleepwalker the mental brain is in general partially awake, and it is the stimulus derived from the waking portion which rouses the cerebellum and the automatic brain to action. Hence the somnambulist frequently has in view the attainment of some object with which in the normal waking state his thoughts have been much occupied. Still there is no conscious sight, properly so called; for it is only when he is roused that he becomes aware of the presence of surrounding objects, and recognises, it may be, the danger of his position. The day-dreamer, again, is allied to the somnambulist. When the mind is intensely occupied, the senses watch over the safety of the individual, almost, it may be said, without his consciousness. The eye detects obstacles in his path, the ear recognises sounds behind him, and makes him unconsciously turn aside; and after a certain time he is roused up by finding himself at his destination, but cannot tell how he has reached it. It is worthy of remark that the cerebrum may afterwards recognise impressions, of which, at the moment of their production, it seemed unconscious. The physical eye of a person absorbed in thought, for instance, may see an object of which, at the time, there is no mental perception, but of having seen which he becomes conscious as soon as the train of thought has passed away.

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* Some interesting facts in regard to the cerebella of fishes will be found in Owen's Lectures on the Vertebrate Animals, vol. i. p. 188.

† On the Functions of the Cerebellum, by Drs Gall, Vimont, and Broussais. Translated from the French by George Combe. Edinburgh, 1838.

Observations on Mental Derangement, by Andrew Combe, M.D., pp. 161 and 248. Edinburgh, 1831.

The Brain and its Physiology: a Critical Disquisition on the Methods of determining the Relations subsisting between the Structure and Functions of the Encephalon. By Daniel Noble. Pp. 133–146. London, 1846.

* Somnambulists are frequently described as walking with shut eyes. Shakspeare, in his description of Lady Macbeth, is more true to nature:—

> "*Gentlewoman.* Since his majesty went into the field, I have seen her rise from her bed, throw her nightgown upon her, unlock her closet, take forth paper, fold it, write upon't, read it, afterwards seal it, and again return to bed; yet all this while in a most fast sleep.
>
> *Doctor.* A great perturbation in nature! to receive at once the benefit of sleep, and do the effects of watching! In this slumbery agitation, besides her walking and other actual performances, what, at any time, have you heard her say?
>
> *Gent.* That, Sir, which I will not report after her.
>
> *Doct.* You may, to me: and 'tis most meet you should.
>
> *Gent.* Neither to you, nor any one; having no witness to confirm my speech.
>
> *Enter Lady Macbeth, with a taper.*
>
> Lo you, here she comes! This is her very guise; and, upon my life, fast asleep. Observe her: stand close.
>
> *Doct.* How came she by that light?
>
> *Gent.* Why, it stood by her. She has light by her continually; 'tis her command.
>
> *Doct.* You see, her eyes are open.
>
> *Gent.* Ay, but their sense is shut."

Macbeth, Act v., Scene 1.

A curious case, mentioned by Dr Cowan of Reading, affords a good illustration of some of the preceding doctrines, and exemplifies, in particular, the action of light and sound as the cause of reflex action. In a letter addressed to Dr Laycock, he says: "I am now attending a lady who evinces the reflex visual and auditory phenomena very strikingly. The shadow of a bird crossing the window, though the blind and bed-curtains are closed, the displacement of the smallest portion of the wick of a candle, the slightest changes in the firelight, induce a sudden jerking of the spinal muscles, extending to the arms and legs when violent, and this without the slightest mental emotion of any kind, beyond a consciousness of the movement. At times the vocal organs are implicated, and a slight cry, quite involuntary, takes place. At these periods she is equally susceptible of all noises, especially the least expected and least familiar. Movements in the next house, inaudible to others, the slightest rattle in the lock of the door, tearing a morsel of paper, and a thousand little sources of sound not to be catalogued, induce similar results to visual impressions. Tactile sensibility is also great at these periods, though not to an equal extent. These peculiarities rapidly vary, and at times she is quite able to bear any amount of light or noise. Her mental powers are good, and she can exert considerable power over herself. . . . . The sensorial impression, and the motion consequent upon it, appear irrespective of any painful sensation or mental emotion, and are only noticed by the patient in consequence of the resulting movement. I have very closely questioned and observed on these points, and have no doubt that under certain states of health, the slightest conceivable influences affecting either the eye or ear, under the circumstances I have described, do induce, apart from all pain or mental intervention, sudden contraction of the spinal muscles, in a perfectly similar manner to the contraction following the application of a stimulus to a paralysed limb."*

We have likened the automatic brain to an instrument which acts in obedience to stimuli derived from various sources. These stimuli vary in nature according to the molecular structure of the nervous filaments which conduct them. If, for example, we pinch a nerve of common sensation, certain reflex movements are produced, because we have applied to the nerve a stimulus which it is capable of transmitting. But if, on the other hand, we irritate the nervous substance of the cerebrum, no muscular action ensues, because the cerebral filaments are constructed to convey only the stimulus which results from cerebral or mental action. This mental stimulus varies with the part of the cerebrum which is in action, and according to the degree of the cerebral excitement.

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* Lancet, 1845, vol. ii., p. 364.

The cerebrum accordingly is composed of a variety of distinct parts, each having its own appropriate function, and generating a nervous power peculiar to itself. In its anterior region are the organs of the intellectual faculties, and in the superior region those of the moral feelings; and it is as impossible for one portion of the cerebrum to undertake the office of another portion, as it is for the cerebellum to perform the functions of the cerebrum, or for the cerebrum to perform those of the medulla oblongata.

The fact has already been noticed, that a ludicrous idea may prove so strong a stimulus as to overcome the counteracting stimulus of the will; and the same remark is applicable to the action of many emotional stimuli. Thus, in anger the voice becomes tremulous and husky, and we strive in vain to assume a calm unmoved tone. In cases of danger, the play of the muscles of the countenance betrays our mental feelings, notwithstanding our utmost efforts to appear unconcerned. Joy shortens the face and grief lengthens it, according to the stimulus transmitted from the cerebrum to the automatic brain; and the laughter and the sobbing which accompany these two mental conditions are as decidedly reflex movements as is the scratching of the side of the decapitated alligator on mechanical irritation of its skin. To a certain extent, reflex movements having their origin either in physical or mental stimuli are under the control of volition. We may, for example, by an effort of the will, check the natural or reflex impulse to close the eye on the approach of a foreign body; and in like manner we may prevent the appearance on our countenance of the reflex results of joy or fear. But we can do so only by the substitution of a stronger mental stimulus; that is, by causing the will to prevail over the emotion.

The consideration of this subject naturally leads us to endeavour to elucidate the phenomena of volition and self-control. In a normally constituted brain, the power of acting according to the choice of the will may be termed the result of such a harmonious action of the component parts of the cerebrum, that no individual part shall acquire excessive energy. When this harmony is disturbed by the over-action of some one part of the cerebrum, the will may lose its ascendency, and an involuntary action may ensue. For instance, in the case of the ludicrous idea, already repeatedly referred to, the power of the will to control our laughter may be more than neutralised by the powerful stimulus which has been applied to that part of the cerebrum which is connected with the feeling of the ludicrous; till the will is reinforced by the opposite action of some other part of the cerebrum, manifested by such feelings as the fear of giving offence, the dread of punishment, a sudden fright, &c. The laughter is then checked in a moment, simply because the new cerebral action enables the will to prevail. In the case of any intense impulse, we are hurried on to action by a cerebral stimulus which may result in a voluntary act, but which does so only while we can restrain the mental action by the aid of other portions of the cerebrum. Thus, one choleric man may be carried away by overpowering passion to commit some deed of violence; while another, equally choleric, may be restrained by *the foresight and fear of the consequences*—that is, by states of mind implying a counteracting cerebral action. This difference of behaviour is the result of the greater development or activity of the organs of the reasoning faculties, and of Cautiousness, in the one than in the other; and thus the one is more capable than the other of "doing what he would."

The direction which the will takes is greatly dependent on the predominance and cultivation of certain of the cerebral organs. The original conformation of a man's brain and the education which he has received cause him to adopt certain views, and to be mainly actuated by certain desires and inclinations; while a different sort of education or a differently constituted brain causes another man to adopt entirely opposite views, and to follow opposite inclinations. Neither of these men can at will change his views or desires, but both may nevertheless be induced by some counter influence to act in direct antagonism to them. It may be against a man's convictions of duty to fight a duel, and yet he may be led to do so by pride, or by the fear of being considered a coward. Here one cerebral action prevails over another; but in cases where the two actions are nearly of equal power the individual remains in a state of indecision, now leaning to this side and now to that, and is probably at last determined in his choice by a new cerebral organ being roused to action. On the other hand, where all parts of the cerebrum act in concert, and especially when their action is highly excited, the will acquires an energy and decision which imparts a stimulus of the most powerful kind to the automatic system, and which shews itself in the quick and ready action of the muscles.

During the waking state the cerebral nervous power exerts a constant influence on the automatic system, which acts in obedience to the stimulus thus received. Consequently the prevailing cerebral action is exhibited in the manner and deportment of the individual. Beauty of expression is thus the involuntary representative of a beautiful mind, while a malignant expression proclaims the malevolent passions which habitually hold sway within. In the same way, whenever any particular portion of the cerebrum is roused to action, we find it for the moment give law, as it were, to the automatic system. It is thus that those natural expressions originate, which are the same among every people, and in every clime. The pathognomy or natural language of pride, of anger, of fear, of affection, of determination, of vanity, is everywhere and at all times alike, and its meaning is universally understood. The body thus automatically expresses the operations of the mind, and laughter and weeping are as certainly associated with a mental stimulus applied to the spinal centres, as coughing is with a physical stimulus applied to the peripheral extremities of the nerves, and by them conveyed to the same spinal centres.

When a part of the brain becomes excited from *disease*, or *habitual over-exertion*, the controlling power of the will is greatly diminished or altogether lost, and a man may then cease to be a responsible being. He who commits murder or theft under the stimulus of morbid cerebral excitement, cannot be accounted morally guilty. His subjection to the irresistible morbid stimulus is not more culpable than his inability to resist the cough occasioned by water getting into his wind-pipe.* But a man is culpable if, knowing his besetting sin, he does not try in time to combat it. This may be done by change of circumstances, by the removal of exciting causes, by carefully restraining, as much as possible, the action of the excited organ; and, finally, by diligently cultivating those parts of the brain which either exercise an opposing action, or, by withdrawing the nervous energy from the excited organ, tend to allay its vivacity. Much may be done in youth to remedy a naturally defective character, by giving, as it were, good habits to the brain, and enabling it to resist the approaches of disease or crime; and we daily see how much may be accomplished, even in mature years, by judicious discipline in lunatic-asylums and prisons in restoring a healthy mental condition.*

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* This view may be startling to some readers, but is familiar to all who are practically acquainted with the insane. For elucidations of it, see Phrenological Journal, xv. 63; xvi. 184, 386; xvii. 32; xviii. 375; xix. 227, 249; xx. 163: also Gall on the Functions of the Brain, vol. iv. pp. 99, 221; the works of Pinel, Spurzheim, Prichard, Conolly, Browne, and Thurnam, on Insanity; Rush on the Influence of Physical Causes upon the Moral Faculty; Sampson on Criminal Jurisprudence considered in Relation to Mental Organization; and the Author's Observations on Mental Derangement, p. 257.

Such being the action of the cerebrum on the mechanism of the body, it is but natural to expect that when from original malformation, from disease, or from the contact of poisonous substances conveyed to it in the blood, its action is destroyed, its reflex action on the muscular system will be destroyed likewise. Accordingly we find that in cretinism, in apoplexy, and in cases of narcotic poisoning, all play of the countenance —all expression—is lost; because the adequate cerebral stimulus is no longer transmitted to the automatic system. To a less extent, the same effect is seen in ordinary sleep. In such cases man approaches to the condition of the lower animals; his cerebrum is, in effect, diminished or removed, and, as a consequence, the reflex movements dependent on irritation of the peripheral extremities of the nerves, acquire increased scope from being no longer under the control of cerebral action. For this reason such reflex movements are more decided during sleep than in the waking state, and are much stronger in decapitated than in unmutilated animals. In children, too, convulsions, or irregular reflex movements from the irritation of worms, &c., are much more frequent than in adult age, because the cerebrum is less perfectly constituted in childhood, and consolidates only by slow degrees.

We have already seen that the cerebrum has proportionally a much greater development and influence in man than in the lower animals. Consequently the latter are much more automatic in their movements, and much less under the guidance of the cerebrum. Indeed when we descend sufficiently low in the scale, the cerebrum disappears entirely, and the animal then becomes a mere automaton, which acts in obedience to the innate powers of its nervous system without any choice or will in the matter. The chick, when it chips its shell, and immediately runs to pick up its food, seems to act automatically; but the chick has still a cerebrum, and is, therefore, not so much an automaton as the bee, which, without manifesting any symptoms of intelligence, everywhere forms its comb and collects its honey according to the same undeviating laws. But in man, who acts in obedience to the dictates of the cerebrum, the muscular actions of adaptation are more the result of practice than of originally implanted power. Even walking must be so acquired, and we see, in the act of writing, a familiar proof that much practice and study are necessary to enable the cerebrum, through the instrumentality of the cerebellum, to communicate to the automatic nervous centre the precise amount of stimulus required. By long practice the automatic centre acquires so great a facility in performing the behests of the cerebrum, that we almost cease to trace in them the action of the will. For instance, when we are engrossed by thought, our fingers, almost unconsciously to us, trace the letters with the pen. Such habitual movements, from the constant and unvarying way in which they are performed, might almost be termed the acquired automatic. In man, however, no movement is beyond the cerebral influence, however closely it may approach the pure automatic; and without the related cerebral stimulus certain modifications of action cannot be acquired: thus, a man very deficient in musical ability, cannot learn to modify his muscular action so as to produce good music on the violin or piano. Of the inevitable effects of cerebral influence on the automatic movements we have evidence in the involuntary sobbing of grief, which interrupts the action of the respiratory muscles; and in the palpitation of the heart which accompanies mental emotion.

In states of great excitement, either the cerebral stimulus is erroneously communicated to the automatic centre, or the power of communicating it is altogether lost. In such cases, either inappropriate muscular contractions, or none at all, are produced. The most familiar example of this is the stammering or loss of speech which accompanies great mental excitement and the simultaneous action of opposite emotions. It also occasionally happens that the automatic centres are in such a state of morbid excitement, that the slightest stimulus, whether mental or physical, suffices to throw the body into convulsions. Thus, in hydrophobia, even the stimulus of a breath of air on the surface, or the mental state produced by the sight of water, is sufficient to cause the most violent convulsive paroxysms.

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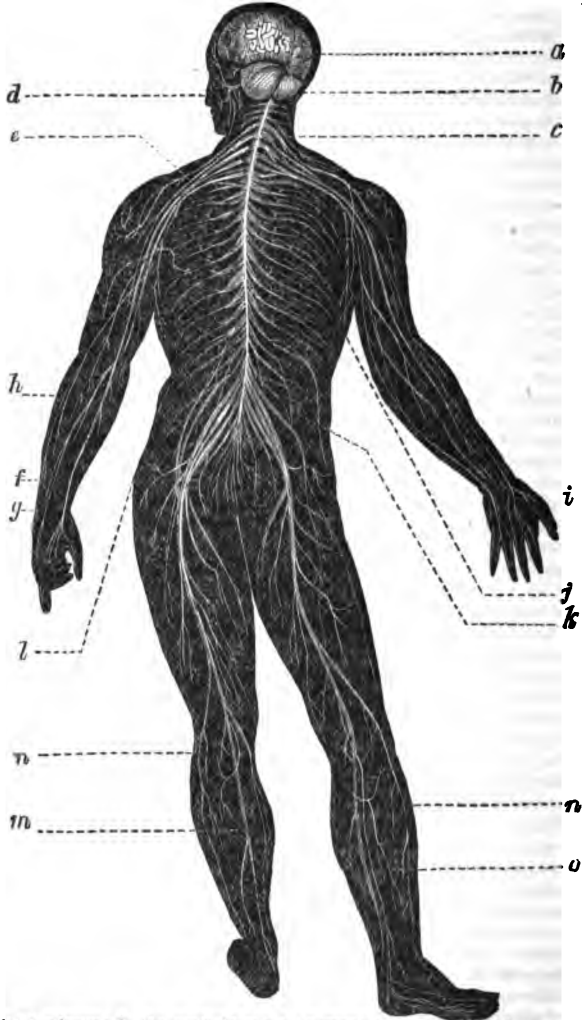
* See a little work entitled "On Man's Power over himself to prevent or control Insanity. By the Rev. John Barlow, M.A." London, 1843.

We know that the mental brain is capable of education; and there is every reason to think that this capability is enjoyed likewise by the automatic centres. In no other way can we satisfactorily explain the habitual and almost unconscious performance of acts which were learned at first with much conscious effort. When we try to write with the left hand, we find that the will alone is not sufficient to produce our usual style of writing. We must have an educated and practised instrument capable of carrying into effect the mandates it receives from the will; and this power is evidently dependent partly on the nervous and partly on the muscular system. The nervous centres must be taught to select the particular nervous fibres necessary to carry the required stimulus, and the muscles be educated to respond correctly to the stimulus conveyed to them. That this is really a matter of education, appears from the difficulty which we at first experience in performing separately muscular contractions which are usually associated; as, for instance, when we endeavour to move the ring-finger apart from all the others. It appears also from the difficulty which some individuals experience in directing the motor stimulus to the proper fibres in articulating, and which thus produces habitual stammering. This defect is capable of removal when the attention is strongly directed towards it, and a powerful voluntary effort is made to pronounce slowly and deliberately. By an effort of the will we may disguise our habitual handwriting; but in both cases, when the mind is otherwise engaged, and the attention withdrawn, the habitual style of writing and the habitual stuttering return. The permanent removal of the latter can be effected only by an effort which is continued till the habit of correct speaking overcomes the habit of stammering. In early childhood this may be accomplished with tolerable facility, but at a later age the struggle sufficiently to command the attention is generally ineffectual. It is, therefore, of the utmost consequence to check at once, and most decidedly, every indication in a child to stammer, which it frequently does from imitation. Squinting also occasionally originates in imitation or trick, and accordingly may often be checked at the beginning, by firmness on the part of the parent, before the tendency becomes confirmed.

If we allow the capability of education to the automatic brain, it will explain also the performance of many movements of adaptation during sleep and in states of unconsciousness, which cannot be the result of mere reflex action; such as, of drawing up the bed-clothes to cover a part which has been accidentally exposed, changing the position in bed, and so on.

From the consideration of the nervous centres we pass to that of the NERVES, through which these centres issue their mandates, and receive the knowledge of external impressions. They are seen in the woodcut (fig 24) passing from the nervous centres to every part of the body; and, in fig. 18, p. 230, which exhibits the base of the brain, the cerebral nerves may be seen arising from the medulla oblongata and cephalic ganglia. Of these the long-looking nerve *a a* (fig. 18), lying on the lower surface of the anterior lobe, is the *olfactory nerve*, or nerve of smell, going to the nose. The round thick nerve 4 4, near the roots of the former, is the *optic nerve*, or nerve of vision, going to the eye. That marked *b* is the *motor nerve* which supplies the muscles of the eyeball. A little farther back, the fifth pair *c* is

Fig. 24.



a, the cerebrum; *b*, the cerebellum; *c*, the spinal cord, giving off the various spinal nerves as it descends; *d*, the facial nerve; *e*, the brachial plexus formed by the junction of several spinal nerves; *f*, *g*, *h*, *i*, nerves of the arm and forearm; *j*, intercostal nerves; *k*, the lumbar plexus; and *l*, the sacral plexus, formed by the junction of several spinal nerves. The latter gives off the great sciatic nerve which divides into *m*, *n*, *o*, the nerves of the leg.

seen to issue apparently from the arch D, called *pons Varolii*. It is a large compound nerve, and divides into three branches, which are ramified on almost all the parts connected with the head and face, and the upper and under jaw. It comprehends fibres of both sensation and motion, and one branch of it ramified on the tongue is by many supposed to be the nerve of taste. Other branches supply and give sensibility to the teeth, glands, and skin. The seventh or *auditory* nerve *e*, is distributed on the internal ear, and serves for hearing. The eighth or *pneumogastric* nerve *d*, sends filaments to the windpipe, lungs, heart, and stomach, and is one of great importance in the production of the voice and respiration. It also influences the action of the heart, and the process of digestion. These various nerves are also seen in fig. 21, p. 233. The uses of the spinal nerves have already been explained in the chapter on the muscles, page 92.

Various nerves, then, it appears, have various functions, which are dependent partly on the nature of their peripheral expansion, partly on the structure of the nerves themselves, but principally on the central ganglionic body in which they terminate. Thus, in order to ensure sight, the impression of light must be received by the retina, and be transmitted by the optic nerve to the optic lobes of the brain (part of the cephalic ganglia), which alone are capable of taking cognisance of it, and converting it into sight. Even supposing that light could produce an impression upon any other nerve, and that this impression could be propagated to the brain, still no sight would be produced, because the centre which received the impression would be that specially appertaining to the stimulated nerve, and would respond to the stimulus according to its own laws of action, but remain incapable of assuming the functions of any other centre. According to this view, it is physically impossible that the functions of the optic nerve can be undertaken by any other nerve, and all alleged cases to this effect must be regarded as fallacies. Should it ever be proved possible to read the pages of a closed book, or to describe the contents of a sealed box, the solution of the mystery will probably be found in the discovery of another sense,—such, for instance, as the power of recognising the electrical state of bodies. We all know that a magnet exercises its influence through an intervening board; and supposing the human body to possess the means of recognising this influence,—as by our eyes we possess the means of recognising light,—we may thus be enabled to recognise the presence of bodies from which a magnetic or electric force issues, though separated from us by opaque media. It is, however, extremely improbable that the human body ever has any such power, as its possession apparently would be in opposition to the natural laws which govern the action of the other senses.

Before quitting this part of the subject, it may be useful to the reader to state generally, that *the nerves of animal life* serve chiefly to place the mind and its organ the brain in communication with the external world; and that their importance may be best understood by imagining what man would be without them. Suppose, for example, that any one were suddenly deprived of the services of the nerves of sight, hearing, touch, taste, and smell, and that, retaining all his *internal* powers of emotion and thought unimpaired, he were, from the destruction of his muscular nerves, also to lose the power of regulating his own movements, what would be the result, and how long could he exist? Is it not clear that he would be left in the midst of creation in a darkness, silence, and death, compared with which the awful solitude of "the last man" would be a pleasurable and social crowd? Without nerves to convey to the brain the impressions derived from external objects, no interchange whatever of thought or feeling could take place between man and man, and no image from without ever reach the mind. Unless the nerves of sight and hearing announce to our consciousness the entrance of our friend, we must remain unmoved and unaffected by his presence; and unless the muscular nerves were ready to obey the commands of the will, we could no more extend a hand to welcome him or give expression to our joy, than if we lay in a swoon powerless at his feet. In this way the mind and body are equally dependent on each other. Without a brain to think, and nerves, muscles, and bones to execute, the mind would be, so far as we are concerned, powerless and useless. And, on the other hand, these organs, without mind to guide and direct them in their exercise, would be, like the paralysed limb, an unmeaning and motionless encumbrance.

Such, then, is a brief outline of the uses of the brain and nerves. The study of the functions of the nerves abounds in interest and attractions for every intelligent mind; but as their more minute investigation would lead us too far from the objects more immediately in view, we must, for the present, quit the subject, and return to the consideration of the brain, which, as the organ through which all the mental operations are carried on, and by the condition of which they are continually influenced, possesses claims upon our attention which it is impossible to overrate.

As already remarked, all physiologists are agreed that the brain is the organ of the mind, and that during life its co-operation is as indispensable to the active manifestations of the mental faculties as the eye is to the sense of sight, or the ear to that of hearing. But for practical purposes, it is extremely important to go a step farther than this general fact, and ascertain whether, in manifesting the mind, the brain acts as a single organ in *every* mental operation, or whether it is really, as we have described it, an aggregate of different parts, each constituting the organ of a distinct power of the mind, in the same way as each of the organs of the external senses is appropriated to its special function. On this question, also, there is now scarcely any diversity of opinion, as almost all observers concur in considering the latter to be the correct view; and even those who deny the minuter subdivisions indicated by the phrenologists, mostly agree in regarding the anterior lobe as the special seat of the *intellect*, and the other parts of the brain as the seat of the passions and moral feelings. There are so few exceptions to the general belief of these propositions, that I consider myself fairly entitled to hold them as established; particularly as the phrenologists have succeeded in demonstrating their truth by a mass of evidence which, when carefully examined, it is impossible successfully to resist.

If this were the proper place for the discussion, it would not be difficult to adduce very conclusive evidence in favour of the proposition, that every primary mental power, whether of intellect or of feeling, has a portion of the brain specially appropriated for its own exercise. The unity of the mind itself has been thought by some to be incompatible with its acting through the medium of a plurality of organs; but this argument becomes entirely without weight when we consider the analogous case of the external senses, each of which has its own distinct and appropriate organ—the eye, the ear, the nose, &c.—although the mind, which sees, hears, and smells, is a unit. Even were there no other evidence, therefore, the analogy of the senses would itself render it in the highest degree probable that each mental faculty acts through the medium of a special cerebral organ. Hence, instead of detaining the reader with any of the numerous proofs which might easily be adduced were this the place for them, I shall for the present assume the principle as established, and content myself with one or two illustrations of the expediency of keeping it in view in all practical treatment in which the mind is concerned.

As man is constituted at present, when any one of the five senses is exercised singly and to excess, it alone and its special organ become exhausted from the fatigue, and the rest of them remain as ready for active employment as if the whole five had been entirely at rest. Hence, when we wish to cultivate acuteness in any one sense exclusively, we must exercise it frequently, but never continue its activity so long at one time as to exhaust its energies. By following this method we shall succeed in developing the wished for acuteness, more readily than if we restricted the exercise exclusively to the one, and continued it without intermission. Every one is aware of this, because, the organs of the external senses being visible, it is easy to discover that one or more may act while the rest are in repose; and that, for example, when we are tired with *looking* intently at any thing, we may nevertheless *listen*, or *taste*, or *smell*, with great pleasure and refreshment. This arrangement is attended with the great advantage not only that our information regarding external objects is multiplied, and rendered accurate, in proportion to the number of senses by which their different qualities are recognised, but that when, from necessity or inadvertence, any particular organ is lost, its place may in a considerable measure be supplied by augmented action on the part of the others. In the same way, when some faculty of the mind is wearied by long-continued exercise, we find a source of enjoyment in the exercise of others. It is thus, for instance, that the harassed man of business finds recreation in reading or in music; for when the mind has been intently dwelling on some particular object, we seek distraction not in simple rest, but in exercising those faculties which have been lying quiescent. It was by persevering application in the study of the individual faculties that Dr Gall was ultimately enabled to place the true physiology of the brain upon a solid and permanent foundation, by demonstrating beyond the possibility of reasonable doubt its grand principle, that the brain is not a single organ, serving as a whole for the manifestation of all the faculties of the mind equally, but is, on the contrary, an aggregate of many different parts, each subserving one, and only one, individual mental faculty, exactly as one external organ subserves the sense of touch, another that of sight, and a third that of hearing—instead of a single organ being sufficient for all. The different organs of the brain are not indeed so distinctly separated from each other as are those of the external senses; because their very functions require their conjunction, and not their separation. The external senses are so distinct in function that we may conceive of any one of them acting without the associated action of any of the others: we may hear without seeing, smelling, tasting, or touching the object which emits the sound; or we may see without hearing anything. But the internal faculties of the mind are too closely connected to admit of such isolated action, and it is impossible for us in any circumstances to call into play only one feeling or one intellectual faculty at a time. Do what we like, and check it as we may, no single internal power or emotion can start into activity without several others being instantly associated in the action. One feeling or thought rouses another in spite of our utmost efforts at suppression; and hence guilt or shame, for example, is often unwittingly betrayed by excited fear, when the culprit would almost give up life itself to be able to prevent its exhibition. In exact accordance with this mode of operation of, and intimate union between, the internal faculties, we find that, as might have been expected, the closest union subsists among their respective organs in the brain, and that it is as impossible to delineate their precise local boundaries, although their situations are known, as it is to define the functions of each with mathematical precision. Yet, strange to say, this harmony of relation between structure and function has been dwelt upon by many as an insuperable objection to phrenology. The alleged organs, it is argued, cannot be such, because in nature we see no boundary line between them. But such objections have been set aside by the progress of modern physiology. "Although," says Professor Valentin, "the most numerous intercommunications and reciprocal actions take place in the central organs of the nervous system, it is, on careful examination, apparent that these results are dependent on the action of particular nervous regions, or perhaps even on that of particular nervous cells. The elementary tissues in the brain lie in close proximity, and although different central organs occupy different localities, no intervening foreign mass occurs to mark their divisions and separate the various regions. But to keep the nervous influence duly regulated, and prevent it from passing into purposeless disordered action, there must be some means of confining it to the operation required. Hence it is probable that every minute department of the central nervous system acts independently, and that its action is extended either by propagation along its own peculiar fibres, or by exciting allied nervous cells. It depends on the amount and nature of the molecular changes thus induced how far and to what nervous departments the action shall be communicated."* Objectors to these views forget that in the case of the nerves of sensation and motion, the consentaneous action of which is in most cases so essential to the regulation of our movements, there exists a not less intimate connection of fibres performing distinct functions; and that it was this apparent unity of the two sets of nervous fibres, which so long misled physiologists to the belief that the same nervous fibres served for both. This hasty inference was arrived at in opposition to the physiological phenomena, that sensation may be lost while the power of motion remains, and that the power of motion may be destroyed while sensation remains undiminished.

In concluding these very general remarks, it is fit to remind the reader once more that the knowledge as yet accumulated of the nervous system is most imperfect, and that the foregoing sketch must be regarded as but a meagre outline of a subject which it would require volumes to elucidate. Any further attempt to do so, in the small space at our command, would, we fear, tend more to confuse the non-professional reader than to enlighten him.

When we come to treat of the applications of the physiology of the brain and nervous system to the purposes of human improvement, we shall perceive the importance of keeping the principle of their subdivision in view as a practical guide. At present I shall merely remark, that the simple axiom now recognised in comparative anatomy, *that no single organ can execute more than one distinct function*, is of itself sufficient to prove that one organ cannot serve for the operation of all the mental powers. Accordingly, even the *Edinburgh Review*, which, on more than one occasion, has evinced great hostility to some of the above views, as included among those of the phrenologists, has at another time powerfully inculcated them as acknowledged physiological truths. Undeterred by the statement in one volume, that we have no evidence that the brain is at all concerned in any mental acts except those connected with the external senses,* a reviewer expressly and truly asserts in another, that, exactly in proportion as we ascend in the scale of creation, and the animal acquires a sense, a power, or an instinct, do its nerves multiply, and "its brain improve in structure and augment in volume; *each addition being marked by some addition to, or amplification of, the powers of the animal, until in man we behold it possessing some parts of which animals are destitute, and wanting none which they possess*;" so *that* "*we are enabled to associate every faculty which gives superiority with some addition to the nervous mass, even from the smallest indications of sensation and will, up to*

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* Lehrbuch, vol. ii., part 2, p. 709.

* Edinburgh Review, vol. xliv., p. 257.

the highest degree of sensibility, judgment, and expression."* It is thus that while many animals possess individual senses or instincts in greater perfection than man, there is not one which can be compared with him in the number and range of its faculties; and, concurrently with this, there is not one which approaches him in the development and perfection of its nervous system.

The mind and brain being thus so closely associated during life, that the former acts in strict obedience to the laws which regulate the latter, it becomes an object of primary importance in education to discover what those laws are, in order that we may adapt our conduct to them, and escape the numerous evils consequent on disregarding them. To this inquiry I shall devote the following chapter, and begin with those laws which apply to the brain considered as a whole.

CHAPTER XIII.

CONDITIONS OF HEALTH OF THE BRAIN—LAWS OF MENTAL EXERCISE.

THE principal conditions on which the health of the brain depends may be divided into two great classes,—the one having reference to its nature as a constituent part of the living organism, and the other to the peculiar and important functions which it performs. Under the first head may be included every thing which directly affects the nutrition and physical well-being of the brain: while under the latter may be comprehended whatever affects the brain through the medium of the mind. In ordinary language, the former may be designated as the *physical* or *organic*, and the latter as the *mental* or *functional* conditions of cerebral health. In strictness, however, both may be termed organic, since mental causes produce disease only by inducing changes in the brain itself; but as the distinction will be useful in practice, I do not hesitate to adopt it.

If we inquire attentively by what peculiarities those individuals have been distinguished who have enjoyed a high degree of mental and bodily health throughout a long and active life, we shall find that, with scarcely an exception, they have inherited from their progenitors a sound constitution of both mind and body. The reflecting reader, therefore, will not be surprised that among the *organic conditions* by which the health of the brain is most directly secured, I should name first, the possession of a *sound hereditary constitution.* Experience shews, indeed, that the importance of this condition, as a preservative, can scarcely be overrated. Where it is possessed, and where no unusual susceptibility of disease has been generated by mismanagement in early infancy, it constitutes by far the most efficient safeguard which any human being can obtain of future cerebral and mental health under whatever circumstances of trial and anxiety he may be afterwards placed. Where, on the other hand, it is wanting, and an individual has the misfortune to be sent into the world with a brain and nervous system on which the peculiarities of insane, eccentric, or highly excitable parents are strongly imprinted—and especially where injudicious treatment in childhood has aggravated the original defect—the most careful and rational management in after life will often fail to prevent the invasion of nervous misery or mental derangement, from causes to which those more soundly constituted may be habitually exposed without injury to either mind or body. Let it never be forgotten, then, that the transmission of a *hereditary* tendency from parents to children, producing in the latter an unusual liability to the maladies under which the parents have laboured, is one of the most powerful causes which *predispose* to cerebral and mental disease.

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* Edinburgh Review, vol. xlvii., p. 442, 443.

Even where the original defect in the parent is merely some peculiarity of disposition or temper, amounting perhaps to eccentricity, it is astonishing how clearly its influence on some one or other of the progeny may often be traced, and how completely a constitutional bias of this description may interfere with a man's happiness or success in life. I have seen instances in which it pervaded every member of a family, and others in which it affected only one or two. When the original eccentricity is on the mother's side, and she is gifted with much force of character, the evil extends more widely among the children than when it is on the father's side. Where both parents are descended from tainted families, the progeny is, of course, more deeply affected than where one of them is from a pure stock; and, seemingly for this reason, hereditary predisposition is a more usual cause of nervous disease in the higher classes, who intermarry much with each other, than in the lower, who have a wider choice. As an illustration of what has just been said, we may quote the following remarkable instance of hereditary defects, although the case occurred in one of the lower animals. It is related by Mr Bree in the *Magazine of Natural History*, from which it is quoted by Dr Graves.* "A white cat of the Persian breed was kept in Mr Bree's family as a favourite. The animal was a female, quite white and perfectly deaf. She produced at various times many litters of kittens, of which some were white, others more or less mottled, tabby, &c., &c. But the extraordinary circumstance is, that of the offspring produced at one and the same birth, such as were, like the mother, entirely white, were, like her, invariably deaf; while those that had the least speck of colour on their fur, as invariably possessed the usual faculty of hearing." This case shews in a very striking manner the tendency which Nature has to repeat in the offspring the qualities of the parent. It pervades alike the animal and vegetable kingdoms, and is extensively made use of by agriculturists to improve both their crops of grain and breeds of cattle. When we speak of hereditary diseases, then, we merely mean a tendency which belongs to the offspring to pass through the same phases of development as the parent, especially when it is placed under circumstances similar to those of the parent. It is frequently found, for instance, that the offspring of a parent who became insane in middle life remains of sane mind till it reaches the same stage of existence, when it also begins to shew symptoms of mental derangement. It is accordingly of the utmost consequence that the external circumstances of the offspring should be varied from those of the parent, so as to modify as far as possible the parental type, and aid Nature in her endeavours to regain her original healthy standard. Under favourable circumstances there is a constant progress towards a higher and improved development; and so powerful is this tendency in man, that were due attention paid to the laws of his nature, all hereditary disposition to disease would speedily be overcome.

Unhappily, it is not merely as a cause of disease that hereditary predisposition is to be dreaded. The obstacles which it throws in the way of permanent recovery are even more formidable, and can never be entirely removed; and hence the direct interest we have in avoiding the perpetuation of the mischief by imprudent intermarriages. If two persons, each naturally of an excitable and delicate nervous temperament, choose to unite for life, and especially if they marry at a very early age, when the natural excitability of the system is at the highest, it will be almost impossible to prevent the concentrated influence of these peculiarities from destroying the health of their offspring, and subjecting them to all the miseries of nervous disease, madness, or melancholy.

Even where no hereditary defect exists, the state of the mother during pregnancy has an influence on the mental character and health of the offspring of which few parents have any adequate conception, but with which every mother ought to be familiar. In my work on Mental Derangement, I referred in proof of this fact, to the testimony of the late M. Esquirol, whose talent, general accuracy, and extensive experience, give great weight to all his well-considered opinions. It is often, he says, in the maternal womb that we are to look for the true cause, not only of imbecility, but also of the different kinds of mania. During the agitated periods of the French revolution, many women then pregnant, and whose minds were kept constantly on the stretch by the anxiety and alarm inseparable from the epoch at which they lived, and whose nervous systems were thereby rendered irritable in the highest degree compatible with sanity, were afterwards delivered of infants whose brains and nervous systems had been affected to such a degree by the state of their parent, that in future life, as children they were subject to spasms, convulsions, and other nervous affections, and in youth to imbecility or dementia, almost without any exciting cause. The extent to which the temporary state of the mother during gestation may influence the health of the offspring appears very forcibly from the following facts. The number of still-born children in Paris amounted, during the years 1812, 13, and 14, on an average to 1232. In the last year the allied armies appeared under the walls of the city, and for some time the inhabitants were kept in a state of great agitation. The result was that the number of still-born children rose in 1815 to 1920. Nor was this all. The mortality of infants under three months amounted in 1815 to 5192; during the three preceding years it had been on an average 2855. When the offspring produced in such circumstances survives infancy, its whole future life frequently bears witness to the influence of the mother's condition during pregnancy on its welfare, of which some idea may be formed from a single fact recorded by M. Esquirol. A pregnant woman, otherwise healthy, was greatly alarmed and terrified by the threats of her husband, when in a state of intoxication. She was afterwards delivered, at the usual time, of a very delicate child. The child had, however, been so much affected by its mother's agitation, that, up to the age of eighteen, it continued subject to panic terrors, and then became completely maniacal. The nervous timidity of James VI., so ludicrously exhibited by Sir Walter Scott in *The Fortunes of Nigel*, is said to have had a similar origin. Hobbes the philosopher is another example. He was born at Malmesbury, in Wiltshire, on 5th April 1588, when the southern coast of England was threatened by the Spanish Armada. The approach of this formidable fleet terrified his mother so much as to cause her premature delivery; "an accident," says one of his biographers, "which may account for that fearfulness which possessed her son in so remarkable a degree, and which he humorously acknowledges in his own narrative of his life in elegiac verse:—

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* Clin. Lec., vol. i., p. 508.

> Atque metum tantum concepit tunc mea mater,
> Ut pareret geminos, Meque Metumque simul.

This circumstance too may have caused that delicate state of health which attended him till near his fortieth year, and obliged him to observe those rules of temperance and exercise by which his life was prolonged to the unusual period of ninety years."* I have myself seen several instances of the same kind, and among others one of a young lady, whose extreme nervous sensibility was partly attributable to prolonged excitement and alarm in her mother, who, when pregnant with her, spent several days half immersed in water during a storm at sea, and in hourly expectation of shipwreck and death. Such persons, including many whose systems have been weakened by long-continued disregard of the laws of health, "are commonly called nervous; they are worried with trifles; startled at shadows; distracted by noise or bustle; never free from some ache or pain, for almost every feeling is suffering; and what in others would be slight pain, in these amounts to agony. Hence they are perpetual invalids, quite unfit for the rugged path of life, over which they, as it were, walk barefooted and thin-skinned. If real disease attack them, its nervous symptoms are so much exaggerated, that a medical attendant is apt to fall into the error of either ascribing all to the nerves, or of measuring the disease by the severity of the symptoms."*

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* Life prefixed to Hobbes's Treatise on Human Nature, edit. 1812.

The causes which most materially tend to produce this excited state of the nervous system in previously healthy constitutions, are the confinement and luxurious habits of the upper classes, whose nervous systems are cultivated at the expense of the rest of their bodies. Occasionally an analogous state is produced by the over-active treatment of disease, in cases where the system is damaged by the too copious abstraction of blood. In both cases, imperfect nutrition of the nervous system lies at the root of the evil, which can be removed only by long and persevering observance of the general laws of health, such as we have endeavoured to expound in the previous chapters of this work. When the fault lies in original defect of the nervous system, the evil may frequently be mitigated by judicious treatment, but can scarcely ever be removed.

An opposite condition to that just described is frequently observed in individuals whose muscular system is cultivated at the expense of the nervous, or who, from congenital constitution, or from age, are deficient in sensibility. Such individuals, says Professor Williams, "feel less than other folk. All their feelings are obtuse, and their action slow; they have no intense suffering or pleasure. Such persons have also little irritability, but much tone of fibre, and are remarkable for their immunity from many diseases." They contrast with the over-sensitive in this respect also, that while the sufferings of the latter are due in no inconsiderable degree to deficiency of blood, or an alteration in its quality, *their* dulness is frequently due to an overcharged state of the blood-vessels.

Hence, the condition on which the health of the brain most directly depends, after that of its congenital constitution, is undoubtedly a due supply of well-constituted blood. The effects of slight differences in the quality of the blood are not easily recognised, but, when extreme, they are too obvious to be overlooked. If the stimulus of arterial blood be altogether withdrawn, the brain ceases to act, and sensibility and consciousness become extinct. Thus, when carbonic acid gas is inhaled, the blood circulating through the lungs does not undergo that process of oxygenation which is essential to life; and as it is in this state unfit to support the action of the brain, the mental functions become impaired, and death speedily closes the scene. If, on the other hand, the blood be too highly oxygenated, as by breathing oxygen gas instead of common air, the brain is too much stimulated, and an intensity of action bordering on inflammation takes place.

Such are the consequences of the two extremes; but the slighter variations in the state of the blood have equally sure, although less palpable effects. If its vitality be impaired by breathing an atmosphere so much vitiated as to be insufficient to produce the proper degree of oxygenation, the blood then affords an imperfect stimulus to the brain, and, as a necessary consequence, langour and inactivity of the mental and nervous functions ensue, and a tendency to headache, syncope, or hysteria, makes its appearance. This is seen every day in the listlessness and apathy prevalent in crowded and ill-ventilated schools; and in the headaches and liability to fainting which are so sure to attack persons of a delicate habit in the contaminated atmospheres of crowded theatres, churches, and assemblies. It is seen less strikingly, but more permanently, in the irritable and sensitive condition of the inmates of cotton manufactories and public hospitals, and in the lethargy which, especially in the morning, affects the occupants of small confined bed-rooms. In these instances the operation of the principle cannot be disputed; for the langour and nervous debility consequent on confinement in ill-ventilated apartments, or in air vitiated by the breath of many people, are neither more nor less than minor degrees of the same process of poisoning to which I have formerly alluded. It is not constitutional debility which produces them; for unless the exposure has been very long, egress to the open air almost instantly restores activity and vigour to both mind and body. In cases of disease also, the influence of pure air upon the action of the brain is not less remarkable. The late Dr A. T. Thomson, in his little work on *The Management of the Sick-Room*, mentions having "seen patients labouring under high delirium in a close ill-ventilated room, become rapidly collected by merely lowering the heat of the apartment twelve or fifteen degrees." (P. 117.) The improvement here was doubtless partially due to the lowering of the temperature, but principally to the admission of fresh air. Other testimony to the same effect might easily be produced.

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* Williams' Principles of Medicine, 2d ed., p. 79.

But impure air is not the only medium through which the brain is deprived of a proper supply of well-constituted and nutritious blood. Want of wholesome food, and defective powers of digestion, are equally influential in impairing the vital properties of that fluid; and hence, at all periods of life, but especially in childhood and youth, when the brain, in common with other organs, is in a state of great activity and rapid development, the proper management of diet is a subject of the greatest practical importance. In my other works* I have fully explained the mode in which defective nourishment impairs the powers of the mind by weakening the brain, and unfolded the principles by which diet should be regulated at different periods of life, so as to secure the highest bodily and mental health of which the constitution is capable. But there are still one or two circumstances to which, from their practical importance, and from their being often overlooked in the dietetic arrangements for the young, I must again solicit the attention of the reader.

In my work on Digestion, I have shewn that, in conformity with the great activity of growth and nutrition in early youth, the craving for food returns much sooner than in mature age; and that, to sustain the healthy vigour of the system, a wholesome and substantial dinner ought to follow within at most five hours after breakfast. When, as often happens from a bad arrangement of the school-hours, dinner is postponed much beyond this interval, and only some slight refreshment is allowed in the forenoon, the inevitable result of the want of due sustenance is, that the system becomes proportionally exhausted, and the mind itself impaired in energy and activity. Where much constitutional delicacy exists at the same time, the health also suffers slowly but certainly. In boarding-schools such results are frequently observed, especially in winter, when the teacher is sometimes induced by the shortness of the day to omit muscular exercise altogether, and to postpone dinner to a late hour, with the view of having all the lessons over before darkness comes on. I have known this arrangement adopted at the solicitation of the pupils themselves, who were too ignorant to perceive the evils which it entailed upon them, and who ought never to have been indulged in a way so prejudicial to their own welfare. In one instance in which continued bad health was thus induced, it resisted all the curative efforts of the physician and the parents, so long as the cause was left in operation; but recovery began from the moment that a more rational plan was adopted at my suggestion. By a simple change of hours, and allowing a long interval at mid-day for an early dinner, the boy was enabled to continue his education without interruption, although his health had suffered so much that the parents had made up their minds to remove him from school and send him to the country, as the only probable means of saving his life.

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* On Digestion and Diet, and on the Physiological and Moral Management of Infancy.

Another form in which the brain, in common with the rest of the body, often suffers from defective nutrition in early life, consists in neglect of sufficient relaxation during, and for some time after, eating. In many schools and families, books are taken up, lessons resumed, or tasks begun, almost immediately after meals, instead of an interval of relaxation being allowed to facilitate digestion and give the system the full benefit of the food. In some institutions, indeed, so desirous are the teachers that no moment of time should pass unimproved, that some one reads aloud during meals; all cheerful conversation is thus prevented, and the digestive powers are weakened by the nervous influence being withdrawn from the stomach. The evil, too, falls most heavily on those children who can least withstand it; on those, namely, whose nervous systems are already excited, and whose attention is most easily roused. Strong healthy children may resist this cause of impaired health; but it often injures very seriously the more delicately constituted, and helps to ruin both the stomach and the nervous system. But it would lead me too far from the proper object of this work to go more minutely into its consideration here, and the reader is referred for additional information, to p. 113 of the 9th edition of my work on Digestion.

Those who have never reflected on the influence of a well-arranged diet and sound digestion on the health of the brain and mental functions, may obtain some idea of its reality from the examination of extreme cases. Starvation, for example, is well known to affect the brain so much as often to produce ferocious delirium. This result was painfully exemplified not many years ago, after the wreck of the Medusa French frigate on the coast of Africa, when, under the influence of hunger, scenes of cruelty and horror took place which it is impossible to read of without shuddering. Among the Milanese, also, a species of insanity arising from defective nourishment is very prevalent, and is easily cured by the nourishing diet provided in the hospitals to which the patients are sent. I have seen the mental functions weakened, and the brain disordered, by the same cause—inadequate nutrition—at the period of rapid growth. This defective nutrition, however, it must be observed, does not always depend on want of proper food. On the contrary, it is often the result, among the higher classes, of too much or too stimulating food, over-exciting and ultimately impairing the digestive powers. The result, in both cases, is the same, namely, imperfect constitution of the blood, and consequently imperfect nutrition of the tissues of the body.

Chemical investigation shews that in many diseases the constitution of the blood deviates very much from the healthy standard, and we can readily understand how the stimulus of diseased blood to the brain and other parts of the nervous system, should be followed by symptoms of so-called nervous diseases. We have already mentioned that in cases of hysteria the blood is frequently found deficient in red corpuscles, and that the symptoms of the disease disappear as the blood regains its normal constitution. Hysteria, then, though called a *nervous* disease from its most striking symptoms, is in reality, at least in many instances, one of *nutrition;* and the fundamental remedy is to be sought, not in antispasmodic drugs, but in attention to the general laws of health. The same remarks are applicable to many cases of hypochondriasis, when dissipation or excess of business has sapped the powers of the system. The blanched cheek and lacklustre eye shew the alteration which the blood has undergone, whence it no longer affords a normal stimulus to the brain. This is one cause of those feelings of unconquerable melancholy which so frequently lead to suicide. We thus see at once the source of the benefit so frequently derived from the temporary renunciation of pleasure or business, and seeking a remedy in country air and change of scene, or whatever else is deemed calculated to improve nutrition.

In hydrophobia we have an example of a nervous disease (apparently due to alteration of the blood, produced by inoculation with a specific poison), in which the symptoms, those of intense nervous excitement, are limited almost entirely to the spinal cord. The least breath of air is sufficient to excite the most fearful convulsions, which increase in intensity till death ensues.

The proneness to morbid action of the brain, induced by imperfect nutrition, is one cause why, in times of public distress, the suffering poor are so apt to resort to violence to remove the sources of their discontent. The brain, weakened by want of food, becomes liable to excitement, and ceases to exercise its accustomed self-control. But where actual famine has been endured, the excitement speedily subsides into torpor, and the sufferer passes the time in a state of lethargy, the blood ceasing to afford any stimulus whatever to the brain, beyond what is sufficient to produce a dreamy state of consciousness. "It is most remarkable," says a writer in the *Times*, when speaking of the Irish famine, "how difficult this disease (starvation) makes it to hazard any opinion as to the age of the sufferers. The girls and women bear it better than the males. The most piteous class to look upon are the children from four to ten years of age—they lie so quiet, and seem so patient in their mere skin and bones. I seldom heard one cry. As soon as they become confined to their beds you scarce ever find them in anything but a half-dozing state. Those who look upon them must suffer — they themselves seem beyond it."*

But there still remains to be noticed one of the most frequent causes of an altered condition of the blood, namely, *the abuse of spirituous liquors.* Every one is familiar with the effects produced by intoxication. The spirit introduced into the stomach is speedily absorbed and carried into the blood, which, thus contaminated, acts more or less injuriously upon all the organs of the body, but principally on the nervous system,—producing, in the first place, an excited action, which is afterwards followed by a corresponding depression, and this in its turn produces a craving for a fresh supply of the stimulus. It is thus that the habit of drinking is formed—a habit which, when once acquired, but few are able to break. Its evils are too well known, but they may be briefly summed up as including impairment of the functions of the digestive organs, enfeebling of the automatic nervous system, and the moral and intellectual degradation of the drunkard. Experience shews the difficulty—we may almost say impossibility—of weaning habitual drunkards from their favourite vice. The efforts of temperance societies may doubtless prove serviceable in this respect, but alone they will fail to remedy an evil which, notwithstanding all their past labours, continues to increase. In their endeavour to combat it they have too generally overlooked the mental constitution of man. "Vows of celibacy have never eradicated lust; of fasting, gluttony; of poverty, avarice; of humility, ambition. The thoughtful, the enlightened, the religious, will not require a vow of total abstinence to keep them temperate; the ignorant, the untaught, the irreligious, will too frequently take the vow to break it."* Fifty years ago the vice of excessive drinking was very prevalent in the middle and upper ranks of society. It has now almost entirely disappeared there; but this result is due not to the efforts of temperance societies, but to increased knowledge and civilization, and the introduction or increase of many rational means of recreation.

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* The Times, July 9, 1849.

* See an excellent article on this subject in the Brit. and For. Med.-Chir. Review, vol. vii.

The same remedies will remove drunkenness from the mass of the people. Cultivation of their intellects will cause them to seek higher sources of enjoyment; and their moral faculties, no longer obscured and perverted by the use of pernicious stimuli, will seek refreshment in the peace and comfort of their homes. The great error that has hitherto been committed lies in our wishing to think and act for the people, instead of educating them to think and act for themselves, and aiding them in their endeavours to provide suitable means of recreation when the labours of the day are over. Till this fundamental mistake be corrected the multitude will make little progress; let it be so, and they will soon work out their own salvation. In the mean time, advantage may be taken of the compound nature of the human mind to break or weaken the habit of drinking of such as cannot now be educated, by placing various recreations and amusements within their reach. Cheap railway-trips, pedestrian excursions, out-of-door pastimes, and musical performances, are calculated to be of much benefit in this respect; as, indeed, is any amusement or employment which will give pleasing and harmless occupation to the various faculties of the mind. To attempt to cure drinking by such proceedings as shutting the spirit-shops, is to view the matter superficially, and to grapple with the effect instead of the cause.

But important as is the *quality* of the blood to the healthy action of the brain, its *quantity* and the regularity of its supply are of scarcely inferior consequence. Some of the preceding illustrations bear still more forcibly on this point than on the influence of defective quality. I now add, that if, as often happens from accidental wounds, and during blood-letting, the quantity of blood circulating through the brain be suddenly diminished, the effect may be so great as entirely to arrest its action and destroy consciousness. Even where the loss of blood, although considerable, is not sufficient to produce this result, it will nevertheless impair the vitality of the brain, and often lower the mental vigour so much as for a time to unfit the individual for active or energetic thinking. When, on the contrary, the circulation of the blood through the brain is accelerated within certain limits, increased action and its accompaniment increased mental activity, are the certain results. In this respect the brain is situated precisely as is every other organ of the body. When not stimulated by a full supply of well-constituted blood, it acts feebly and imperfectly. Thus Sir A. Cooper found that, when the carotid and vertebral arteries which convey the blood to the brain were tied, the animal experimented upon became stupid, and, to a certain extent, incapable of voluntary motion. On the other hand, when a full supply is afforded, the brain becomes proportionally excited to higher activity, till, if this condition be carried to excess, the excitement may end in violent delirium or maniacal furor.

Over-fulness of blood, however, is frequently accompanied by torpor of the intellectual faculties, owing to the pressure exerted by the gorged blood-vessels on the brain. In such cases the risk of apoplexy becomes imminent, and no time should be lost in having recourse to a restricted diet, and, if necessary, to bleeding and purging to reduce the quantity of blood. It is under such circumstances that vegetable diet is found to be so beneficial, producing, as it then does, an unwonted activity of intellect and feeling of lightness,—because, by the continued use of such diet, the quantity of blood is reduced, and the pressure on the brain diminished. Under the opposite circumstances of impoverished blood from poor or deficient food, a vegetable diet would only aggravate the evil.

The law, in virtue of which excitement of function and activity of circulation in the organ performing it are always coincident, being thus as applicable to the brain as to all other organs, common prudence requires, that, in conducting both physical and mental education, we should take the fact into account, and regulate our management so as to prevent either deficiency or excess in the cerebral circulation, and to preserve it as far as possible in that equable state which is so manifestly conducive to the health of the brain. But as few non-medical readers are at all aware of the necessary relation which really subsists between organic and mental activity, I shall adduce two or three illustrative facts before attempting to explain the physiological law which connects them together, and which is calculated to afford us much assistance as a practical guide.

In some parts of the body the increased circulation which always accompanies excitement of function may be made the direct subject of experiment. When, for instance, we use the eye too long, or in too bright a light, it is soon observed to become bloodshot, and the increased action of its vessels and nerves gives rise to a sensation of fatigue and pain requiring us to desist. If we turn away the eye, the irritation gradually subsides, and the healthy state returns; but if we continue to look intently, or resume our employment before the eye has regained its natural state by repose, the irritation at last becomes permanent, and disease, followed by weakness of sight or even blindness, may ensue—as often happens to glass-blowers, smiths, and others, who are obliged to work in an intense light.

Precisely analogous phenomena occur when, from intense mental excitement, the brain is kept long in a state of excessive activity. The only difference is, that we can always see what happens in the eye, but rarely what takes place in the brain. Occasionally, however, cases of fracture of the skull occur, in which, from part of the bone being removed, we can *see* the quickened circulation in the vessels of the brain as easily as those of the eye. Sir Astley Cooper had a young gentleman brought to him who had lost a portion of his skull just above the eyebrow. "On examining the head," says Sir Astley, "I distinctly saw the pulsation of the brain was regular and slow; but at this time he was agitated by some opposition to his wishes, and *directly the blood was sent with increased force to the brain, the pulsation became frequent and violent; if, therefore, you omit to keep the mind free from agitation, your other means will be unavailing*" in the treatment of injuries of the brain.* A still more remarkable case is mentioned by Dr Caldwell, as having occurred to Dr Pierquin in the hospital of Montpellier in 1821. "The subject of it was a female at the age of twenty-six, who had lost a large portion of her scalp, skull-bone, and dura mater, in a neglected attack of lues venerea. A corresponding portion of her brain was consequently bare, and subject to inspection. When she was in a *dreamless sleep* her brain was *motionless*, and *lay within* the cranium. When her sleep was *imperfect* and she was agitated by dreams, her brain *moved* and *protruded without* the cranium, forming *cerebral hernia*. In *vivid* dreams, reported as such by herself, the protrusion was considerable; and when she was perfectly awake, especially if engaged in active thought or sprightly conversation, it was still greater."† This protrusion arose, of course, from the greater quantity of blood sent to the brain during its activity, than when it was quiet: and if the case be accurately reported, it certainly is one of the most interesting on record.

To these cases, as published in the early editions, I may add another which was reported about ten years ago in Mr Combe's *Notes on the United States* (vol. ii., p. 279). The patient, a daughter of Mr Mapes of New York, fell from a window when about four years of age, and had her skull so severely fractured, that portions of it, to the extent in all of about three inches square, were removed near the crown of the head. The brain was of course uncovered to the same extent, and in the region of the organs of Self-Esteem and Love of Approbation.

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* See Sir A. Cooper's Lect. on Surg. by Tyrrel, vol. i., p. 276.

† Annals of Phrenology, vol. i., p. 37. Boston, U.S., 1833.

At the time of Mr Combe's visit, the girl was eight years old. The skin over the wound was thin and covered with fine hair; on applying the hand over it a curious leech-like motion was felt in the brain, accompanied with a prominence and pulsation of the part whenever the corresponding feelings were excited. When the feelings were at rest, and her intellect alone was active, as when intent on solving an arithmetical question, only the gentle and equal pulsation of the arterial system was perceptible.

In all of these cases, mental activity and increased circulation were found invariably to accompany each other.

The well known impulse given to thought and feeling by wine and other stimulants, which act chiefly by increasing the flow of blood to the brain, is but another example of the operation of the same general law, and goes far to justify the opinion of Dr Caldwell, that, if it were "possible, without doing an injury to other parts, to augment the constant afflux of healthy arterial blood to the brain, the mental operations would be invigorated by it. I state," says he, "this opinion confidently, because we often witness its verification. When a public speaker is flushed and heated in debate, his mind works more freely and powerfully than at any other time. Why? Because his brain is in better tune. What has thus suddenly improved its condition? An increased current of blood into it, produced by the excitement of its own increased action. That the blood does, on such occasions, flow more copiously into the brain, no one can doubt who is at all acquainted with the cerebral sensations which the orator himself experiences at the time, or who witnesses the unusual fulness and flush of his countenance, the dewiness, flashing, and protrusion of his eye, and the throbbing of his temporal and carotid arteries. It is well known that, while intensely engaged in a memorable debate last winter in Washington, a distinguished senator became so giddy, by the inordinate rushing of blood into his brain, that he was obliged to sit down, and the senate adjourned to give him time to recover. And, more recently, a new member in the House of Representatives fell while speaking, and suddenly expired from the same cause. A member of the law class of Transylvania, moreover, experienced, a few weeks ago, a convulsive affection from a congestion of blood in the head, induced by excessive excitement of the brain in the ardour of debate."* In many instances, indeed, the increased circulation in the brain, attendant on high mental excitement, reveals itself by its effects when least expected, and leaves traces after death which are but too legible. How many public men, like Whitbread, Romilly, Castlereagh, and Canning, urged on by ambition or natural eagerness of mind, have been suddenly arrested in their career, by the inordinate action of the brain induced by incessant toil! And how many more have had their mental power for ever impaired by similar excess! When tasked beyond its strength, the eye becomes insensible to light, and no longer conveys any impressions to the mind. In like manner, the brain, when much exhausted, becomes incapable of thought, and consciousness is almost lost in a feeling of utter confusion. To the hard-working literary man, cerebral rest on Sunday is of no less utility than muscular rest is to the miner or coal-heaver. "During many years' observation of intellectual labourers," says a London journalist, "we never knew a man to work seven days in the week who did not kill himself, or kill his mind." And it deserves to be seriously considered whether young people who are busily occupied during six days of the week with study, should be burdened, so much as they frequently are in Scotland, with Sunday "*tasks*," demanding such painful efforts in committing to memory the prescribed portions of abstruse theological works and ill-understood hymns, that the day of rest and refreshment, in place of being a

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* Caldwell's Thoughts on Physical Education, p. 114.

"delight," as it ought to be, is looked forward to with a feeling of aversion, which is apt to extend to religion itself.

In delicate persons, and in invalids recovering from severe illness, the influence of the quantity of blood upon the action of the brain is often very marked; a mere change from the horizontal to the sitting position will often be sufficient to induce fainting, simply from the want of sufficient blood in the brain to sustain its action. From the same cause, mental power may be impaired without being actually extinguished. A case of this kind was communicated to me by an experienced teacher in England, in which the effect of change of position on the brain was so great that the boy seemed to be of "two different characters" when sitting and when lying. In the former attitude, when the brain was scantily supplied with blood, he was inactive and looked apathetic and sullen; whereas, when he lay down, and the circulation was not impeded by the gravity of the blood, his real powers of mind became manifest, and he was "animated, talkative, and highly intelligent." This case deserves attention, both because it is in itself of a striking nature, and because it was not communicated as an illustration of the point under discussion, but merely in reference to the general discipline of the institution. An analogous case is mentioned by Lévy, of a man who had no memory except when lying with the head very low.

Some distinguished authors have found the horizontal position most favourable to felicitous composition. Thus Lévy tells us that the late Professor Goupil of Strasburg prepared his brilliant lectures while recumbent; and Sir Walter Scott says "that the half hour between waking and rising has all my life proved propitious to any task that was exercising my invention. When I got over any difficulty in a story, or have had in former times to fill up a passage in a poem, it was always when I first opened my eyes that the desired ideas thronged upon me. This is so much the case, that I am in the habit of relying upon it, and saying to myself when I am at a loss:—'Never mind! we shall have it at seven o'clock to-morrow morning.' If I have forgot a circumstance, or a name, or a copy of verses, it is the same thing."* This effect, however, may have resulted to a considerable extent from the invigoration of the brain by sleep.

Such are the principal *organic* conditions on which the health of the brain depends. We now come to the consideration of its *functional* or *mental* conditions.

When treating of the laws of exercise (see pages 118 and 137), and explaining the changes which take place in every organ of the body when it is called into activity, or, in other words, when its function is exercised, I took some pains to shew, 1*st*, That when an organ is left too long inactive, the circulation of blood through its vessels becomes feeble and imperfect, and the organ itself impaired in tone, and unfit to act with ease or energy; 2*dly*, That when an organ is regularly and duly exercised, it receives a proportionably copious supply of blood, and acquires a healthy and vigorous tone, with a corresponding aptitude for free and ready action; and, *lastly*, That when functional exercise is carried to excess, or is repeated without sufficient intervals of repose, the circulation through the organ becomes unduly accelerated, and that, as a consequence, the function becomes excited, and is carried on with an energy and activity which are apt to exceed the limits of health, and to induce either disease or exhaustion. From these fundamental principles I deduced the practical rule, that, in our management of ourselves and others, the second degree of exercise is that at which we ought stedfastly to aim, and from which alone we can expect beneficial results. I have now to shew that this practical inference applies with equal force to *the brain* as to other organs; and that, in endeavouring to promote its health, we must either regulate the exercise of all its functions by the ordinary laws of physiology, or forfeit the advantages which their observance is destined to confer upon us.

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* Diary of Sir Walter Scott in Lockhart's Life. Feb. 10, 1826.

Since, as I have already shewn, not only are increased activity of brain, and an increased flow of blood through its vessels, inseparably connected, but within certain limits the one is always proportioned to the other, it follows that, as the function of the brain is to manifest the various powers of the mind, *activity of mind* necessarily implies a corresponding *activity of brain*, and is attended with all its physiological results. Or, in other words, activity of mind is as much the mode of exercise of the brain as walking is of the muscles, or vision of the eye; and it is only by keeping this fact steadily in view that we can see our way clearly through the inconsistencies of different educational theories, and arrive at principles sufficient for our own guidance. Let us now see how far the ordinary laws of physiology apply to the exercise of the cerebral functions.

That *inactivity of the brain* impairs its healthy energy, and, as a necessary consequence, diminishes mental power, is amply proved by daily and hourly experience. Nor will this truth surprise any reflecting person who keeps in mind that, by disuse, muscles become emaciated and weakened, blood-vessels and nerves obliterated, and bone itself softened and altered in structure; and who considers, that, as a part of the same animal system, the brain is nourished by the same blood, and subjected to the same vital laws, as the muscles, bones, and nerves. For direct proof, however, I need only refer the reader to the well known influence of solitary confinement upon the bodily and mental condition of even the most energetic and robust. Solitary confinement impairs and destroys mental vigour solely by the forced inaction into which it throws the brain; and unless relieved by occupation and the occasional visits of the attendants, it becomes the most destructive punishment which can be inflicted upon any human being. Under its unmitigated infliction, the strong-minded man soon lapses into the feebleness of childhood, and the sternest resolution yields like the willow to the gentlest breeze.

It is from a similar cause that men accustomed for years to a busy and bustling life, almost inevitably become hypochondriacal, melancholy, and enfeebled in mind and resolution, on retiring from business or from active public service to the quiet of the country, without any pursuit to occupy their attention. The brain and mind, being left in inaction, soon lose their healthy tone, and indolence and ennui appear where calm enjoyment was confidently, but most unreasonably, looked for. It is the same cause which renders that seclusion from society, which invalids are apt to indulge in, so injurious to both bodily and mental soundness; and which often renders the situation of governesses one of misery and bad health, even where every kindness is meant to be shewn towards them. In many families, especially in the higher ranks, the governess lives so secluded, that she is almost as much out of society as if she were placed in solitary confinement. For the same reason, those who are cut off from social converse by any bodily infirmity, often become discontented and morose in spite of every resolution to the contrary. The feelings and faculties of the mind, which had formerly full play in their intercourse with their fellow-creatures, have no longer scope for sufficient exercise; and the almost inevitable result is irritability and weakness in the corresponding parts of the brain.

Ennui and inactivity thus directly contribute to shorten life, and furnish another example of the adaptation by Divine wisdom of all things to each other. The human system is arranged on the principle of acting in harmony with the requirements of man's social position, and health and activity thus go hand in hand. Ennui and inactivity imply that man has nothing to do worth living for; and such being the case, the mechanism begins to rust and decay, just as a machine made by man does when left unemployed. When loss of means, or other so-called misfortunes, oblige the man of ennui and idleness to exert his powers actively, health and strength return, and his prospect of life improves.

We have a remarkable example of the atrophy of organs following their entire disuse, in the blindness of the fishes which live in the waters of the dark caves of the Tyrol and Kentucky. There is much reason to think that in them the non-development of the visual organs is the result of constant deprivation of light, the long-continued operation of which cause has made blindness their natural condition. It would be a highly interesting experiment to try if removal to light would, in the course of generations, restore the sense of sight.

These principles are further illustrated by what is observed among the deaf and blind, in whom, from their being precluded from a full participation in the same sources of interest as are accessible to their more favoured brethren, irritability, weakness of mind, and idiocy, are known to be much more prevalent than among other classes of people. In the *Dictionnaire de Médecine* (vol. xx., p. 87), Andral gives a description of the deaf and dumb, every word of which bears a direct reference to the above principle; and a similar account has been given of the blind by an equally intelligent observer. "The deaf-mute," says Andral, "presents, in his intelligence, his character, and the development of his passions, certain modifications which depend on his state of isolation in the midst of society. He remains habitually in a state of half childishness, is very credulous, but, like the savage, remains free from many of the prejudices acquired in society. In him the tender feelings are not deep; he appears susceptible neither of strong attachment nor of lively gratitude; pity moves him feebly; he has little emulation, few enjoyments, and few desires. This is what is commonly observed in the deaf and dumb, but the picture is far from being of universal application; some, more happily endowed, are remarkable for the great development of their intellectual and moral nature, but others, on the contrary, remain immersed in complete idiocy." Andral adds, that we must not infer from this, that the deaf and dumb are constitutionally inferior in mind to other men. "*Their powers*," says he, "*are not developed, because they live isolated from society: place them, by some means or other, in relation with their fellow-men, and they will become their equals.*" This is the cause of the rapid brightening up of both mind and features, which is so often observed in blind or deaf children, when transferred from home to public institutions, and there taught the means of converse with their fellows. In these instructive instances, the whole change is from a state of inactivity of the mind and brain to that of their wholesome and regular exercise.

Our next proposition was, that *when all the mental powers are duly and regularly exercised, the brain receives a proportionably copious supply of blood, acquires a healthy and vigorous tone, and becomes fitted for the prompt, free, and energetic action of all the functions appertaining to the mind.* In support of this proposition, I shall enter into no details. Besides its being almost self-evident, proofs of its accuracy are of easy access, and abound everywhere in society to such an extent, that it would be a waste of time to reproduce them here. I shall, therefore, pass at once to the principle implied in the third proposition, namely, that *when mental exercise is carried to excess, either in duration or in frequency, the circulation through the vessels of the brain becomes excited in a corresponding degree, and ultimately induces a state of disease which it is not always easy to remove.*

When the eye has been intently exercised for a length of time without sufficient intervals of repose, it is observed, as I have said, to become blood-shot and unusually sensitive to the light; and if the exercise be persevered in, inflammation and loss of sight may be the ultimate results.

Precisely analogous consequences ensue when the mind is employed to excess. The vessels of the brain become distended, and its action becomes excited, till it borders upon, or actually passes into, disease. At any time of life, accordingly, excessive and long-continued mental exertion is hurtful; but in infancy and early youth, when the structure of the brain is still immature and delicate, permanent mischief is more easily inflicted by injudicious treatment than at any subsequent period—and, in this respect, the analogy is complete between the brain and the other parts of the body, as we have already seen exemplified in the injurious effects of premature exercise of the bones and muscles. Scrofulous and rickety children are the most usual sufferers in this way. They are generally remarkable for large heads, great precocity of understanding, and small delicate bodies. But, in such instances, the great size of the brain and acuteness of mind are the results of morbid growth; and, even with the best management, the child passes the first years of its life constantly on the brink of active disease. Instead, however, of trying to repress its mental activity, the fond parents, misled by the early promise of genius, too often excite it still farther, by unceasing cultivation and the never-failing stimulus of emulation and praise; and finding its progress, for a time, equal to their warmest wishes, they look forward with ecstasy to the day when its talent will break forth and shed a lustre on its name. But in exact proportion as the picture becomes brighter to their fancy, the probability of its being realized becomes less; for the brain, worn out by premature exertion, either becomes diseased or loses its tone, leaving the mental powers slow and depressed for the remainder of life. The expected prodigy is thus ultimately and easily out-stripped in the social race by many whose dull outset promised him an easy victory.

In speaking of children of this description, Dr Brigham, in an excellent little work on the influence of mental excitement on health, published about twenty years ago in America, says: "Dangerous forms of scrofulous disease among children have repeatedly fallen under my observation, for which I could not account in any other way, than by supposing that the brain had been exercised at the expense of other parts of the system, and at a time of life when nature is endeavouring to perfect all the organs of the body; and after the disease commenced, I have seen with grief the influence of the same cause retarding or preventing recovery. I have seen several affecting and melancholy instances of children five or six years of age lingering awhile with diseases from which those less gifted readily recover, and at last dying, notwithstanding the utmost efforts to restore them. During their sickness they constantly manifested a passion for books and mental excitement, and were admired for the maturity of their minds. The chance for the recovery of such precocious children is, in my opinion, small, when attacked by disease; and several medical men have informed me, that their observations had led them to form the same opinion, and have remarked, that in two cases of sickness, if one of the patients was a child of superior and highly cultivated mental powers, and the other one equally sick, but whose mind had not been excited by study, they should feel less confident of the recovery of the former than of the latter. This mental precocity results from an unnatural development of one organ of the body at the expense of the constitution."*

It should constantly be borne in mind, that the immature constitutions of children are much more susceptible of injurious influences than the fully developed systems of adults. Consequently, in disease, when the natural irritability of the young is generally increased, it becomes a matter of paramount importance to remove all sources of excitement. When this is not attended to, and when, moreover, sufficient care is not taken to ensure perfect ventilation, the mortality of such children is found to be much greater than that of sick adults, although the general rate of mortality at the same periods is the reverse. This is especially the case in the Hôpital des Enfants Malades at Paris, where, from the number of children congregated together in wards, it is almost impossible to ensure quiet and purity of air. Accordingly, during the year 1848, the rate of mortality among them was 1 in 5·36, and the average stay in the hospital was 60·51 days; whereas the general rate of mortality in all the Parisian hospitals was 1 in 10·73, and the average stay 27·98 days.* Such facts make it appear extremely doubtful, whether, balancing the evil with the good, the erection of an hospital for sick children, as is at present contemplated in London, would be really beneficial.

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* Remarks on the Influence of Mental Cultivation and Mental Excitement upon Health. By Amariah Brigham, M.D. P. 45. Boston, 1833.

Dr Brigham justly remarks, that it is ignorance in the parents which leads to the too early and excessive cultivation of the minds of children, especially of those who are precocious and delicate; but from the examples which he gives, and the general bearing of his admonitions, the error of commencing systematic education too soon, and stimulating the infant mind too highly, seems to be decidedly more prevalent in the United States than in this country. Among the "children's books" in the United States, many are announced as purposely prepared "for children from *two* to *three* years old!" and among others are "INFANT Manuals" for Botany, Geometry and Astronomy!! That mode of teaching is considered the best which forces on the infant mind at the most rapid rate, without regard to health or any other consideration. In this country, children are not generally sent to school so early; but education is still too much restricted to the exclusive exercise of the mental powers, to the neglect of the physical; and, in the instance of delicate children, is pushed on too rapidly. I have witnessed the fate of one of these early prodigies, and the circumstances were exactly such as those above described. The prematurely developed intellect was admired, and constantly stimulated by injudicious praise, and by daily exhibition to every visiter who chanced to call. Entertaining books were thrown in the way; reading by the fireside encouraged; play and exercise neglected; the diet allowed to be full and heating, and the appetite pampered by every delicacy. The results were, the speedy deterioration of a weak constitution, a high degree of nervous sensibility, deranged digestion, disordered bowels, defective nutrition, and, lastly, *death*, at the very time when the interest excited by the mental precocity was at its height.

Such, however, is the ignorance of most parents on physiological subjects, that when one of these infant prodigies dies from erroneous treatment, it is not unusual to publish a memoir of his life, that other parents may see by what means such transcendent qualities were called forth. Dr Brigham refers to a memoir of this kind, in which the history of John Mooney Mead, aged four years and eleven months, is narrated as approved of by "several judicious persons—ministers and others, all of whom united in the request that it might be published, and all agreed in the opinion, that *a knowledge of the manner in which the child was treated, together with the results, would be profitable both to parents and children, and a benefit to the cause of education.*" This infant philosopher was "taught hymns before he could speak plainly;" "reasoned with" and constantly instructed until his last illness, which, "*without any assignable* cause," put on a violent and unexpected form, and carried him off. As a WARNING not to force education too soon or too fast, this case may be truly "profitable both to parents and children;" but, as an example to be followed, it assuredly cannot be too strongly or loudly condemned. Infant Schools, however, in which physical health and moral training are duly attended to, are excellent institutions. Such are those established and regulated on the plan of the benevolent Wilderspin, whose exertions have gone so far to demonstrate the importance of early infant training. But I regret to say that many schools that have been opened under the same name have scarcely any one sound principle in action; and threaten to do more injury to the children by forced and injudicious intellectual cultivation and close confinement, than will be easily remedied even by the best management in after-life. I know some schools consisting of a single small apartment without any play-ground, and with very imperfect means of ventilation, where upwards of 150 children are crowded together for four or five hours a day, with no free access to the open air,—no adequate muscular or pulmonary exercise,—no mental recreation worthy of the name,—no systematic cultivation of the moral and social feelings in actual intercourse with each other,—and where, with the exception of a few intervals of rest, an occasional march round the room, and a frequent change of subject, the time is consumed in intellectual tasks, to the almost complete exclusion of every thing else. Schools of this description cannot be too strongly denounced as fraught with mischief to the young, and as flagrant abuses of a most valuable principle. But in thus censuring what is radically wrong, we must be careful not to go to the other extreme, and, like Cobbett, condemn as bad that which is so only in its abuses. A well-regulated Infant School is an instrument of great power in improving and humanizing mankind.*

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* Annales d'Hygiène Publique. Oct. 1849. P. 387

The ages of the children in the Hôpital des Enfants Malades vary from 2 to 15 years. The great proportion of them are between 5 and 15 years, which constitutes the most healthy period of life.

In the Williams Secular School in Edinburgh, the principles above expounded have been successfully reduced to practice:—"Great care is taken, especially with the younger children, to avoid overtasking the brain. The teacher has found it necessary to make the lessons on mental arithmetic of shorter duration than any of the others, as children of highly nervous temperaments have complained of headache after such lessons, when protracted to the same length as the other lessons. Any undue activity of the brain is at once manifested by a characteristic brightness and restless expression of the eye, generally accompanied with a flush of the cheeks, and a redness and burning of the ears; sometimes there is a red band across the bridge of the nose, or the chin is more flushed than the rest of the face; in all cases the forehead is unusually hot, and frequently headache is complained of. The experience of the teacher has enabled him to detect these symptoms immediately when they present themselves, and to remove the exciting cause.

"It is interesting to observe, that while the general mental activity of the children has so greatly increased since the commencement of the school, instances of this kind of morbid activity have become far less frequent, and of late have been almost unknown. A few cases have occurred of highly nervous and excitable children, who for some time after entering the school exhibited continually some of the above named symptoms; but this tendency has gradually subsided, and their general health and robustness have improved, while their intellectual progress has continued very satisfactory; facts which shew strikingly that the system of instruction adopted in the school is safe and healthy, and the tendency to excessive cerebral activity is less than in schools in which tasks to be learned by rote constitute the chief exercises, and in which strong stimulants to love of approbation and fear are applied as means of eliciting exertion. This is easily explained when we consider that the blood, which flows to the head under all circumstances of mental activity, becomes diffused over the whole brain when the action is general, and thus moderate and uniform excitement results; whereas, when only a few organs are active, as in learning lessons by rote, or in mental arithmetic, there must be a tendency to a concentration of the blood upon these parts, and the danger of morbid action is proportionally increased. Thorough ventilation is also carefully attended to, and has a very beneficial effect in warding off drowsiness on the one hand, and undue excitement, from excessive interest in the studies, on the other."*

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* Many of my readers will be glad to learn that Dr Brigham's little work has been reprinted in this country in a very cheap form, with notes by the late Dr Macnish of Glasgow. Dr Caldwell's "Thoughts on Physical Education" has also been republished, with additions from his other writings, and notes by Mr Robert Cox. Both works contain facts and principles of great interest to every parent and teacher, and are calculated to be highly useful in advancing the cause of rational education.

In youth, too, much mischief is done by the long daily periods of attendance at school, by the want of adequate sustenance at an early period of the day, and by the continued application of mind, which the ordinary system of education requires. The law of exercise, that long-sustained action exhausts the vital powers of an organ, applies, I cannot too often repeat, as well to the brain as to the muscles; and hence the necessity of varying the occupations of the young, and allowing frequent intervals of active exercise in the open air, instead of enforcing the continued confinement which is now so common. As might be expected, this exclusive attention to mental culture fails even in its essential object; for experience shews, that, with a rational distribution of employment and exercise, a child will make greater progress than in double the time employed in continuous mental exertion. If the human being were made up of nothing but a brain and nervous system, we might very reasonably content ourselves with sedentary pursuits, and confine ourselves entirely to the mind. But when observation tells us that we have numerous other important organs of motion, sanguification, digestion, circulation, and nutrition, all demanding exercise in the open air, as essential both to their own health and to that of the nervous system, it is worse than folly to shut our eyes to the truth, and to act as if we could, by denying it, alter the constitution of nature, and thereby escape the consequences of our misconduct.

Reason and experience being thus set at nought by both parents and teachers in the management of children, young people naturally grow up with the notion that no such influences as the laws of physiology exist, and that they may follow any course of life which inclination leads them to prefer, without injury to health, provided they avoid what is called dissipation. It is owing to this ignorance, that we find young men of a studious or literary habit enter heedlessly upon an amount of mental exertion, unalleviated by bodily exercise or intervals of repose, which is quite incompatible with the continued enjoyment of a sound mind in a sound body. Such, however, is the effect of the total neglect of all instruction in the laws of the organic frame during early education, that it becomes almost impossible to warn an ardent student against the dangers to which he is exposing himself, and nothing but actual experience will convince him of the truth. From these observations it will be evident how much truth and good sense are contained in the following extract of a letter from Romilly to Roget, dated 12th September 1797. "I am afraid," he writes, "of your prosecuting your studies with more ardour and perseverance than your strength will allow of. I need not certainly impress on your mind one value of life and health, not on your own account alone, but for the sake of those most dear to you. But you really should consider that it is with respect to knowledge as with many other things; by attempting too much we often lose instead of gaining, *and a fortnight of too close occupation may make all study impossible for many weeks and months that follow it.* I have experienced this myself when I was nearly of your age, and have been obliged to expiate by many tedious months of languor and constrained idleness, the imprudent exertions which had exceeded my strength. You ought to reflect that relaxation is to the full as necessary as study to your success, and that the time which appears to be thrown away is really, even with respect to the advancement of your studies, time most profitably employed. I am at this moment putting in practice the doctrine I inculcate; for my only occupation here is to ride about the country, to enjoy the sea-air, and read books of amusement."* To give additional weight to this advice, we shall now quote the experience of a distinguished literary gentleman who seems to have acted in an entirely opposite spirit.

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* Second Annual Report of the Williams Secular School, p. 9. Edinburgh, 1851.

"I have been a workman in my day," says Sir Edward Bulwer Lytton. "I began to write and to toil, and to win some kind of a name, while yet little more than a boy. With strong love for study of books—with yet greater desire to accomplish myself in the study of men—for sixteen years I conceive no life to have been more filled with occupation than mine. What time was not given to action was given to study; what time not given to study, to action—labour in both! To a constitution naturally far from strong, I allowed no pause or respite. *The wear and tear went on without intermission—the whirl of the wheel never ceased.*

"Sometimes, indeed, thoroughly overpowered and exhausted, I sought for escape. The physician said 'Travel,' and I travelled; 'Go into the country,' and I went. But in such attempts at repose all my ailments gathered round me,—made themselves far more palpable and felt. I had no resource but to fly from myself—to fly into the world of books, or thought, or reverie,—to live in some state of being less painful than my own. As long as I was always at work it seemed that I had no leisure to be ill. Quiet was my hell.

"*At length the frame thus long neglected,—patched up for a while by drugs and doctors,—put off and trifled with as an intrusive dun—like a dun who is in his rights,—brought in its arrears crushing and terrible, accumulated through long years; worn out and wasted, the constitution seemed wholly inadequate to meet the demand.*

"The exhaustion of toil and study had been completed by great anxiety and grief. I had watched with alternate hope and fear the lingering and mournful death-bed of my nearest relation and dearest friend—of the person around whom was entwined the strongest affection my life had known—and when all was over, I seemed scarcely able to live myself.

"At this time, about the January of 1844, I was thoroughly shattered. The least attempt at exercise exhausted me. The nerves gave way at the most ordinary excitement—a chronic irritation of that vast surface we call the mucous membrane, which had defied for many years all medical skill, rendered me continually liable to acute attacks, which from their repetition, and the increased feebleness of my frame, might at any time be fatal. Though free from any organic disease of the heart, its action was morbidly restless and painful. My sleep was without refreshment. At morning I rose more weary than I had lain down to rest.

"Without fatiguing you and your readers with the *longa cohors* of my complaints, I pass on to record my struggle to resist them. I have always had a great belief in the power of WILL. What a man determines to do—that in ninety-nine cases out of the hundred I hold that he succeeds in doing. I determined to have some insight into a knowledge I had never obtained since manhood—the knowledge of health.

"I resolutely put away books and study, sought the airs which the physicians deemed most healthful, and adopted the strict regimen on which all the children of Esculapius so wisely insist. In short, I maintained the same general habits as to hours and diet (with the exception of wine, which in moderate quantities seemed to me indispensable), as I afterwards found instituted at hydropathic establishments.

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* Life of Sir Samuel Romilly, vol. ii., p. 61

"I dwell on this to forestall in some degree the common remark of persons not well acquainted with the medical agencies of water—that it is to the regular life which water-patients lead, and not to the aliment itself, that they owe their recovery. Nevertheless, I found that these changes, however salutary in theory, produced little, if any, practical amelioration in my health.

"All invalids know, perhaps, how difficult, under ordinary circumstances, is the alteration of habits from bad to good. The early rising, the walk before breakfast, so delicious in the feelings of freshness and vigour which they bestow upon the strong, often become punishments to the valetudinarian. Headache, languor, a sense of weariness over the eyes, a sinking of the whole system towards noon, which seemed imperiously to demand the dangerous aid of stimulants, were all that I obtained by the morning breeze and the languid stroll by the sea-shore.

"The suspension of study only afflicted me with intolerable ennui, and added to the profound dejection of the spirits. The brain so long accustomed to morbid activity, was but withdrawn from its usual occupations to invent horrors and chimeras. Over the pillow, vainly sought two hours before midnight, hovered no golden sleep. The absence of excitement, however unhealthy, only aggravated the symptoms of ill-health."*

This case is doubly instructive; for we see, in the first place, how the ignorance of physiological knowledge led to the long-continued infringement of the laws of health, and, in the second place, how the same ignorance permitted the delusion that restoration from a state of such long-established suffering could be effected simply by "seeking the airs which the physicians deemed most healthful, and adopting the strict regimen on which all the children of Esculapius so wisely insist." Through a period of long years the frame "had been put off and trifled with as an intrusive dun," till at last it "brought in its arrears, crushing and terrible." The whole system was shattered; every function was impaired. "The physician said 'Travel,' and I travelled; 'Go into the country,' and I went;" but the physician could not remove that ignorance of the laws of the human constitution which had produced the malady, and which still interfered with its removal. To those who have read the chapter on Muscular Exercise in the present work we need not say that the morning walk reluctantly undertaken as a task, and the languid stroll by the sea-side, so far from being in accordance with the laws of health, or even with the rules "instituted in hydropathic establishments," were in reality opposed to both, and decidedly "frauds on the constitution."*

No wonder, then, that from such practice the wretched invalid failed to draw relief. Country air and exercise were in themselves rational prescriptions, but they required to be rationally administered; and even then the improvement to be expected in such a condition could be but slow and fluctuating. Disappointed in his hopes of amendment, Sir Edward had recourse to hydropathy, and in pursuing this system was incidentally placed in circumstances much more favourable to the restoration of healthy action, than those he had previously been in, although they appeared to him to consist of the same "general habits as to hours and diet" which he had formerly pursued. But in reality there were essential differences. The languid stroll by the sea-side which produces no acceleration of the vital metamorphoses, was exchanged for invigorating mountain-exercise, which, by promoting those changes, is so indispensable an adjunct of the water-cure that the system fails on the plain. There was now, moreover, a hopeful mental condition, kept up by cheerful social intercourse, which tended to soothe the morbid excitement of the nervous system, and rendered exercise no longer a burden and a punishment. If to these reasons for improvement we add the occupation of following out the system, the influence of the early hours for meals, and the stimulus imparted to the cutaneous functions by the application of the water, we can readily see good grounds for believing that the patient derived benefit from the water-cure. But no treatment could obliterate all the consequences of his former habits; "I do not even now affect," he says, "to boast of a perfect and complete deliverance from all my ailments." Nor could such a consummation be rationally expected. The "arrears, crushing and terrible, accumulated through long years," could not be liquidated in a week—nor in a month—nor in a year—probably not fully liquidated in all the remaining years of life. There exists no royal road by which the frame, wherein "the tear and wear went on without intermission—the whirl of the wheel never ceased," could be conducted back to health and strength. Nature cannot for ever be evaded like an intrusive dun. Sooner or later she will assert her claims; and the longer the settlement is delayed, the heavier will be the reckoning at last.

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* Confessions of a Water-patient.

* See page 105.

I have seen several instances of insanity, and also of total incapacity for future useful exertion, brought on by long-protracted and severe study, in subjects whose talents, under a better system of cultivation, would have raised them to that eminence, the injudicious pursuit of which had defeated their own object, and ruined their general health. Dr Browne of Dumfries mentions, in the Ninth Annual Report of the Crichton Royal Institution, a patient who, "himself a teacher, trained under a system which enforced continuous application, enjoined an hour's relaxation and eleven of study, or mental application of some kind, and openly professed as an object to condense the greatest possible amount of knowledge into the shortest possible time,—is now exhausted, dejected, dispirited, aged and decrepid in mind, but deluded with the belief that he has accomplished all things." Pope was another remarkable victim of this error. By excessive application, he had reduced his health to such a deplorable state, that he at last gave way to it and prepared to die. "He fell into that state of exhaustion, which Smollett, too, once experienced for half a year, a *coma vigil*—an affection of the brain, when the principle of life is so reduced that all external objects appear as if passing in a dream, —a sort of torpid indistinct existence." Dr Radcliffe heard of his condition, and ordered him to give up study and ride on horseback. Pope fortunately followed the advice, and regained comparative health. In two cases of a similar description which came under my own notice, the sufferers made the remark, that early instruction in the structure and laws of the animal economy, such as that which I am now attempting to communicate, might have saved them. Both meant well, and erred from ignorance more than from headstrong zeal.

As an example, on the other hand, of the advantages that are gained by duly alternating application and relaxation, I may mention that a few years ago the system of granting a month's leave of absence annually to the clerks in the Bank of England was introduced by the Governor, Mr Cotton. It was expected that the change would render an addition of twenty clerks necessary to admit of the Bank's business being properly performed; but experience shewed that no increase whatever was required. The number of absentees from indisposition was so much reduced, and the efficiency of the officers on duty so much increased, that even less difficulty was found in conducting the business of the establishment than before. Instead of being commended, as in former times, for constant attendance at his post without availing himself of the leave of absence, a clerk is now considered as rather doing wrong in neglecting the opportunity of recruiting his strength.

In the first number of the *American Annals of Education* there is an instructive article which strikingly illustrates the preceding exposition. "For twenty years and more," says the writer, in reference to what had taken place in an American seminary, "the unnatural union of sedentary with studious habits, contracted by the monastic system, has been killing in the middle age. The Register of Education shews, in one year, 120 deaths. Examine into the particular cases, and these will be found the undoubted effects of sedentary habits. Look at one name there. He had valuable gifts, perfected by two years' academic, four years' collegiate, and three years' theological studies. *He preached, gave much promise, and then died of a stomach disease. He contracted it when a student.* He did not alternate bodily with mental labour, or he had lived and been a blessing to the church. *When he entered on his studies, he was growing into full size and strength. He sat down till his muscles dwindled, his digestion became disordered, his chest contracted, his lungs congested, and his head liable to periodical pains.* He sat four years in college, and three years in theological application. *Look at him now.* He has gained much useful knowledge, and has improved his talents; he has lost his health. The duties of his mind and heart were done, and faithfully so; but those of his body were left undone. *Three hundred and seventy-five muscles, organs of motion, have been robbed of their appropriate action for nine or ten years, and now they have become, alike with the rest of his frame, the prey of near one hundred and fifty diseased and irritable nerves.*" —"Look at another case. Exposure incident to the parson or missionary has developed the disease in his chest, planted there while fitting himself for usefulness. He contracted a sedentary, while he was gaining a studious habit. That which he sows, that also shall he reap. The east winds give him colds; a pulpit effort causes hoarseness and cough, oppression and pain. He becomes alarmed and nervous. His views of usefulness begin to be limited. *He must now go by direction, and not so much to labour where otherwise he would have been most wanted, as to nurse his broken constitution.* He soon adds to the number of *mysterious providences,*—to the number of innocent victims, rather, of cultivating the mind and heart, at the unnecessary and sinful expense of the body,—to the number of loud calls to alternate mental and corporeal action daily, for the reciprocal sanity and vigour of both body and mind."

In early and middle life, fever, with an unusual degree of cerebral disorder, is a common consequence of the excessive and continued excitement of the brain, which is brought on by severe study, unremitted mental exertion, anxiety, and watching. Some very marked cases of this kind have come under my observation; but that of Sir Humphry Davy is so strikingly illustrative of the dangers alluded to, that I cannot do better than lay it before the reader. In November 1807, that distinguished philosopher was seized with very severe fever, in consequence of the excitement and fatigue which he underwent when engaged in the researches that led to his splendid discovery of the alkaline metals. "The laboratory of the Institution was crowded with persons of every rank and description, and Davy, as may be readily supposed, was kept in a continued state of excitement throughout the day. This circumstance, co-operating with the effects of the fatigue he had previously undergone, produced a most severe fit of illness, which, for a time, caused an awful pause in his researches, broke the thread of his pursuits, and turned his reflections into different channels. Davy ascribed his illness to contagion caught in experimenting on the fumigation of hospitals." "Upon conversing, however, with Dr Babington, who, with Dr Frank, attended Davy throughout his illness, he assured me that there was not the slightest ground for this opinion, and that the fever was evidently the effect of *fatigue and an over-excited brain.* The reader will not feel much hesitation in believing this statement, when he is made acquainted with the habits of Davy at this period. *His intellectual exertions were of the most injurious kind,* and yet, unlike the philosophers of old, he sought not to fortify himself by habits of temperance." "Such was his great celebrity at this period of his career, that persons of the highest rank contended for the honour of his company at dinner, and he did not possess sufficient resolution to resist the gratification thus afforded, although it generally happened that *his pursuits in the laboratory were not suspended until the appointed dinner hour had passed. On his return in the evening, he resumed his chemical labours, and commonly continued them till three or four o'clock in the morning, and yet the servants of the establishment not unfrequently found that he had risen before them.*" Such was the alarming state of his health, that for many weeks his physician regularly visited him four times in the day; and the housekeeper, Mrs Greenwood, never retired to bed except one night during eleven weeks. In the latter part of his illness, "he was reduced to the extreme of weakness, and his mind participated in the debility of his body."[*]

Instances sometimes occur of persons, exhausted by anxiety and long attendance on others, being themselves attacked by fever, and dying, more from the unfavourable state to which previous exhaustion had reduced them, than from the intensity of the fever itself.

Nervous disease from excessive mental labour and exaltation of feeling, sometimes shews itself in another form. From the want of proper intervals of rest, the vascular excitement of the brain, which always accompanies activity of mind, never has time to subside, and a restless irritability of temper and disposition comes on, attended with sleeplessness and anxiety, for which no external cause can be assigned. The symptoms gradually become aggravated, the digestive functions give way, nutrition is impaired, and a sense of wretchedness is constantly present, which often leads to attempts at suicide. While all this is going on, however, the patient will talk or transact business with perfect propriety and accuracy, and no stranger could tell that any thing ails him. But in his intercourse with his intimate friends or physician, the havoc made upon the mind becomes apparent; and, if not speedily arrested, it soon terminates (according to the constitution and circumstances of the individual concerned) in derangement, palsy, apoplexy, fever, suicide, or permanent weakness.

As age advances, moderation in mental exertion becomes still more necessary than in early or mature years. Scipion Pinel, in adverting to the evil consequences of excessive moral or intellectual excitement, acutely remarks, that although in youth and manhood the wear of the brain thus induced may be repaired, no such restorative process follows over-exertion in the decline of life; "*what is lost then is lost for ever.* At that period, we must learn to wait for what the brain is willing to give, and allow it to work at its own time: *to attempt*

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[*] Paris's Life of Sir H. Davy, p. 188. It is proper to mention, that in the "Memoirs of the Life of Sir Humphry Davy," by his brother Dr John Davy, Dr Paris is accused of much exaggeration in what is quoted above. "Instead," says Dr Davy, "of returning to the laboratory after dinner, and working there till a late hour, and resuming his labours after three or four hours' sleep, it was very unusual for my brother to revisit it after he had dressed for dinner, and before breakfast I do not believe he ever entered its precincts. He was never, to the best of my knowledge, in the habit of abridging greatly his hours of rest, which were commonly seven or eight." (Vol i., p. 262.) Dr Davy, however, confirms the statement as to his brother's numerous dinner-engagements, and likewise mentions that his physicians "considered the disease as the result of over-fatigue and excitement from his experimental labours and discoveries." (P. 386.) This opinion was expressed by Dr Babington to Dr Davy himself.

to force it is to weaken it to no purpose; it becomes excited and quickly exhausted when forced to vigorous thinking."—"Men of exalted intellect perish by their brains, and such is the noble end of those whose genius procures for them that immortality which so many ardently desire."*

Who can peruse these lines without the fate of Sir Walter Scott occurring to his mind as a practical illustration of their truth? In the vigour of manhood, few ever wrote so much, or with greater ease. But when, on the verge of old age, adversity forced him to unparalleled exertion, the organic waste could no longer be repaired, and perseverance only "weakened the brain to no purpose," till morbid irritability became the substitute of healthy power, and he perished by that brain which had served him so faithfully and so efficiently, but which could no longer perform with safety the gigantic efforts which he continued to demand from it.

It is well remarked by Tissot, that the disorders produced by the efforts of the mind fall soonest upon such as are incessantly engaged in the contemplation of the same object. In this case, he adds, there is *only one part of the sensorium* (brain) *acted upon, and that is kept always on the stretch; it is not relieved by the action of the other parts, and therefore is sooner fatigued and injured;* the same rule holding with the brain as with the muscles, that the exercise, which, if divided among the different parts of which it is composed, will strengthen them, will, if confined to a few, exhaust and impair them. Boerhaave himself, after a long period of intense thinking, suffered for six weeks from excitement of the brain, bordering on madness, and characterised by that want of sleep, irritability, and indifference to ordinary interests, which so often appear as the harbingers of insanity. Mental labour is also doubly exhausting when it is the offspring of compulsion, and not of spontaneous activity. There is something in the ready fertility of a naturally active mind, which enables it to throw off its ideas with little, if any, injury to the nervous system, when that activity is not carried to morbid excess. But when the brain has become enfeebled by bad health or over-exertion, and it is found necessary to pore over a subject before any ideas can be elicited, then the mental effort becomes very exhausting. "Cudgelling the brains" is the phrase colloquially applied among literary men to this painful and hurtful process. In like manner, I have known mothers in an infirm state of health do themselves irreparable injury by persisting in forced efforts to educate their children, when their natural elasticity of mind had been entirely destroyed by long-continued nervous disease. The loss of tone thus induced gives rise to mental feebleness extremely difficult to remove.

The number of literary and public men, students, and persons in business, who do themselves irreparable injury in a similar manner is so great, that few of my readers who have had experience of the world will be at a loss for examples even among their own acquaintances. In addition to Davy, Scott, and others, already mentioned, Sir Isaac Newton may be referred to, as it is now certain that his mind was for a time disordered by excessive application, and there is much reason to believe that he never altogether recovered from the shock.* The more limited the sphere of talent, the greater the danger of the brain being over-exercised, particularly where the temperament is quick and irritable; and hence the frequency of nervous affections in musicians, and others of susceptible minds, who dedicate their lives to the exclusive cultivation of their arts. It is said that Gretry not only ruined his own health, but lost three highly-gifted and beautiful daughters in succession, from over-excitement of the nervous system thus induced; and there can be no doubt that the melancholy fate of Weber was greatly hastened by intense application. He continued deeply engaged in musical composition long after his health was undermined; and even when the hand of death was almost upon him, his avocations pressed so heavily that he could not help exclaiming, "*Would that I were a tailor, for then I should have a Sunday's holiday!*" The philanthropic physician will rather be inclined to exclaim, "Would that mankind would study their bodily structure and functions, and thus learn to preserve longer the health and existence of those whose genius is the source of so many pleasures to the world at large!"

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* Physiologie de l'Homme Aliéné, p. 177.

* See Brewster's Life of Newton; Phrenological Journal, vol. vii., p. 335; and Edinburgh Review, vol. l., p. 22.

So little, however, is this close connection of the mind with the brain practically understood even by well educated medical men, that instances are constantly occurring among themselves of the health of the nervous system being ruined by excessive application of mind, without the sufferer in the least suspecting the true cause of his ailments. This fact is well exemplified in the following melancholy instance of the ruinous effects of injudicious application which has recently come under my notice, and deserves attention, as its subject was a highly accomplished and well-informed physician. Besides performing numerous professional duties, he was much occupied in the composition of a medical treatise. He became deeply interested in the subject, and was in the habit of pursuing study and composition regularly till two o'clock in the morning, and allowing himself very little time for exercise, digestion, or repose. The natural consequence was a most severe attack of fever, accompanied by epileptic fits and mental prostration, and threatening to result in death, or at least in permanent deterioration of the cerebral powers.

This is no solitary case, for numerous similar instances are recorded in the works of practical physicians, and Dr Forbes Winslow does not hesitate to say that by no class of society are the laws which govern the healthy action of the brain so much neglected as by medical men themselves.* "It is indeed lamentable," says he, "to witness the devastations which have followed a non-recognition of this important law among some of the brightest ornaments of our profession. Let us be wise in time. As we rest the stomach when it presents evidence of its powers having been unduly strained, so let us allow the brain to repose when we feel conscious that its peculiar functions have been severely exercised, and the mind presents deviations from the normal state." That this warning is really needed, Dr Winslow shews by narrating several cases, two of which, as we deeply feel the importance of the subject, we shall here extract.

"A medical gentleman," says he, "was placed under my care by Dr Conolly. He had for some years been occupied in conducting an extensive country practice. Not satisfied with the amount of anxiety necessarily resulting from his professional labours, he was in the habit of sitting up until two or three o'clock in the morning engaged in study. His mind soon became impaired, and committing some acts of extravagance whilst out visiting his patients, he was detained by a magistrate, and, with the consent of his family, was sent to a county asylum. In the course of a few weeks he was transferred to me. The case gave unequivocal indications of mental debility, with obvious incipient paralysis. There could be no doubt of the nature of the case. All who saw the gentleman pronounced him to have softening of the brain. In eight months he left me perfectly restored. Alas! these cures are not of common occurrence."

Again: "A physician, who had been engaged for a period of twenty years in active practice, had been subject for a few years prior to his attack to an unusual degree of mental excitement and hard work. His wife urged him repeatedly to retire from the active duties of his profession, but he declared his intention of dying in harness. The first symptom which he manifested was his mistaking the names of two sisters whom he attended, an unusual thing for him, as he was generally so very particular and precise in all his transactions with them. I was consulted in this case, when, alas! I could hold out no hope of recovery. His wife informed me that before the mental confusion became so apparent as to attract the patient's own observation, ·she had noticed an alteration in his manner, which made her fearful that he was overstraining the powers of his mind. He was observed to be more than ordinarily restless and fidgetty, forgetting his appointments, anxious about trifles, and apprehensive of being left in adverse circumstances. This alteration.in his mental powers was perceptible eight months before the family would believe that anything serious was portending."

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* Psychological Journal, No. vii., p. 31 of Monograph.

Similar cases must have occurred in the practice of every medical man, and the only hope of cure is to be sought in entire REST OF THE BRAIN, combined with change of scene, and appropriate tonic treatment. Great tact on the part of the medical attendant is, however, frequently necessary to persuade the patient to follow the advice which is given. The inability to attend to business is not complete, and the patient cannot be persuaded that his business may be safely carried on without his personal superintendence, although for some time past such superintendence has been productive of more harm than good. It is the duty of every medical man, therefore, to warn his patient of the consequences which overwork is likely to produce, before the setting in of actual disease, and while the mind is yet capable of perceiving the dangers on which he is blindly running. How many valuable lives might thus have been saved to their families and society! for it is in the ranks of the most able, the most active, and the most ardent, that the victims of overtasked brains are most frequently found.

Some years ago a distinguished member of the medical profession in America visited Europe while in the full zenith of usefulness and reputation. During an after-dinner conversation he gave the following reasons for deserting for a year or two a highly remunerative practice. He had remarked, he said, that many of his professional brethren who had for a course of years been actively engaged in practice, and been in a state of health which promised prolonged life, suddenly broke down at the very moment when a career of wealth and honour seemed opened before them. This result he ascribed to the overtasking of the brain, and he determined himself to avoid the evil by taking an interval of rest from all professional cares and anxieties. He returned to America with an invigorated constitution, and has been again for several years engaged in an extensive practice.

I shall take leave of this most important subject by adducing another example, taken from the biography of the late Lord Dudley, and which presents so many instructive particulars in a physiological point of view, that I regret being unable to notice it at greater length. The following extracts from the *Quarterly Review* are, however, so pertinent in themselves, and express so clearly the value of the principles which I have been expounding, that I cannot resist laying them before the reader. After mentioning that Lord Dudley was brought up from his earliest years in a state of entire isolation, the reviewer adds, that "the solitary boy, without brothers, sisters, or playfellows of his own age, became a man in habits while yet a child." "Deprived of out-of-door pastimes congenial to youth, he was driven to his books alone for solace and companionship. The lurking hereditary malady was strengthened by his over-studious and sedentary habits. The irritable susceptibility of the brain was stimulated at the expense of bodily power and health, without which pleasure itself ceases to be pleasure. Dear indeed is knowledge purchased at the expense of happiness. His foolish tutors took a pride in his precocious progress, which they ought to have kept back. They watered the forced plant with the blood of life; they encouraged the violation of Nature's laws, which are not to be broken in vain; they infringed the condition of conjoint moral and physical existence; they imprisoned him in a vicious circle, where the overworked brain injured the stomach, which reacted to the injury of the brain. *They watched the slightest deviation from the rules of logic, and neglected those of dietetics, to which the former are a farce.* They thought of no exercises but in Latin—they gave him a Gradus instead of a cricket-bat, until his mind became too keen for its mortal coil; and the foundation was laid for ill health, derangement of stomach, moral pusillanimity, irresolution, lowness of spirits, and all the Protean miseries of nervous disorders, by which his after-life was haunted, and which are sadly depicted in almost every letter now before us.

"One, indeed, of the boy's many instructors observed the silent operation of these morbid causes, and having learnt Latin to some purpose, pursued the golden rule of education—*Mens sana in corpore sano.* This was a wise man after the manner of Anaxagoras, that respectable ancient, who requested on his death-bed that all the school-boys of Lampsacus might have a month's holidays. He accordingly locked the study-door, threw logic to the dogs, turned his pupil out to grass, and set him to work at the unscholastic pursuit of foxes. He opined that it was bodily exertion and mental inaction which generates the rude health—the '*dura ilia*' of country squires and haymakers, who never fatigue their sensoriums, nor fritter away their nervous energy, nor rob their gastric juices from a mistaken regard to their pia maters. The new instructor, therefore, took the Aristotelian method in this decided case of perversion—he bent the twig in the contrary direction, in the hope of ultimately bringing it to the perpendicular. But unfortunately the news of this prodigious idling ere long reached the ear of the father, who, never interfering except injudiciously, dismissed the tutor who might have saved his pupil; and people of the old stamp continued in function until the *toga quasi-virilis* (of undergraduateship) was assumed.

"The very first lines of Lord Dudley's in the volume before us reveal the sad consequences of this system, already fixed and chronic at the early age of nineteen. Affixed to the portrait is this postscript—'The verses go on *miserably;* YET I neither drink, hunt, shoot, nor fish.' On a smaller peg than this Tissot or Combe would hang a quarto treatise; and truly might Lord Dudley point the moral of their tale, the sure effects of the neglect of the organic laws of physiology." . . . "Lord Dudley 'writes *because he is unable to sleep.*' Well would it have been had the killing 'yet' of the 'postscript' been corrected into *because!*"*

Such is the instructive and melancholy case of Lord Dudley, and such are many more, the details of which are never given to the world. In justice to the reviewer's sagacity, I am bound to confess that, as I read his interesting narrative, I had resolved to "point a moral" with it before I came to the expression of his own opinion that it was truly fitted for the purpose.

CHAPTER XIV.

APPLICATION OF THE PRECEDING PRINCIPLES TO THE HEALTH OF THE BRAIN AND NERVOUS SYSTEM.

In the present chapter I need not enlarge farther upon the means of fulfilling the *organic* conditions of cerebral and nervous health. These have been already sufficiently explained; but a few additional remarks will be required concerning those conditions which, having a direct reference to the manner in which the mind is exercised, may be correctly designated as *mental or functional.*

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* Quarterly Review, vol. lxvii., p. 84–87.

It may be stated as a general fact, confirmed by the widest experience, that functional causes, or those which operate by impairing, exciting, or perverting functional activity, are the most efficient of all in inducing organic disease; and, as a corollary from this proposition, that the well-regulated exercise of the function is one of the best preservatives of organic health. In the case of the eye, for example, the insufficient or excessive exercise of its function, in straining over minute objects, or in exposing the eye to a very bright light, rarely fails, if continued, to induce disease; while the regulated exercise of vision on a variety of objects in a suitable light, and at fit intervals, tends greatly to strengthen and preserve the eye. In like manner, vitiation of the digestive function from aberrations in diet is the most direct cause of disease in the stomach; while its proper exercise in the use of a well-regulated diet in harmony with the constitution and mode of life, is the best safeguard of its health. The same principle applies to the lungs, the liver, and the heart—in all of which, disease is excited by abuse of their respective functions, more readily perhaps than by any other cause.

In this respect, as shewn in the last chapter, the brain, considered as a whole and serving for the operation of all the powers of the mind, constitutes no exception to the general rule; and, accordingly, its health suffers most frequently from causes which disturb its *mode of action*, and is best promoted or restored by the proper regulation of the mental functions. The same rule applies of course to the individual parts of which the brain is composed, each considered as the special organ of an individual mental faculty. Here, consequently, the vast importance of the question, Whether the brain is a single or compound organ? becomes more and more apparent. If, as I have endeavoured to shew (see p. 252), the brain is not a single organ serving equally for the manifestation of the whole mind, but an aggregate of many individual parts, each serving for the operation of a special mental faculty, in the same way as the eye, the ear, and the nose, serve for vision, hearing, and smelling,—it follows that each may be exercised independently, and that, to provide for the health of *the whole* brain, we must secure the direct and adequate exercise of the whole of its component organs by the corresponding exercise of *all* the moral and intellectual faculties specially connected with them. This may seem a very simple and natural proposition; but the evils which flow from its practical neglect are nevertheless very numerous. If, as phrenology proves, and as most physiologists admit, the moral faculties have their seat in one region of the brain, the intellectual powers in another, and the affections and appetites in a third, it is clear that any one of these groups of faculties, and their corresponding cerebral organs, may be exercised singly without the slightest beneficial influence thence necessarily resulting to the other two. By the well-regulated employment of the intellectual faculties, for instance, we may impart strength and readiness of action to the anterior lobe of the brain, where their organs are; and yet, by neglecting the due exercise of the affections and moral sentiments, allow the middle and posterior lobes to become enfeebled by inaction, and, as a consequence, these powers themselves to be impaired in health and vigour. Physiologically speaking, it would be as unreasonable to expect the moral feelings to be strengthened by a cultivation thus restricted to the intellect alone, as to expect any improvement in hearing from the exclusive exercise of vision. For the same reason, it would be absurd to expect the improvement of *all* the moral feelings, or of *all* the intellectual powers, from exercise restricted to any one or only a few of their number. As all of them are capable of independent action, it is clear that *each must be cultivated individually when we wish to promote its development.* The sense of justice may be roused into activity at the same time as the feeling of compassion; but they may also act separately, and the activity of the one is far from necessarily implying that of the other. Pity may even be carried so far as for the moment to weaken and impede the operation of conscientiousness, and the reverse. Hence it is a mere delusion to imagine that we take the surest way to invigorate our moral nature, when we simply make ourselves familiar intellectually with the duty of being honest, kind, and pious. We must be *trained to the habitual practice* of integrity, benevolence, and veneration in our daily life, and see them made the daily standards of conduct of all around us, before these sentiments can acquire the predominant sway which the Creator manifestly designed them to exercise.

I venture thus earnestly to insist upon the necessity of keeping constantly in view the true relation in which each faculty of the mind stands to its individual cerebral organ, because ignorance or neglect of it has been the source, not only of much suffering and bad health, but of most of the errors which have long impaired the practical efficiency of education as a means of human improvement. Hence, instead of the moral faculties being invigorated, and the social affections cherished, by their generous and well-regulated exercise upon their appropriate objects, systematic cultivation is still in a great measure restricted to a few of our inferior propensities,—emulation and the love of gain,—and to such of the intellectual faculties as seem most likely to minister to their gratification. The necessary result is, that neither morally nor intellectually has education yielded the rich fruits which might be obtained from it under a better system of cultivation.

As regards health, also, the frequent consequence of this error has been, that, from limiting mental activity to the excessive exercise of only a few faculties, these few have, under the powerful stimulus of competition and personal ambition, been roused to inordinate action, and occasionally become diseased; while the others, which might have guided or controlled them, have been rendered, by inaction, comparatively powerless. This is the real explanation of Tissot's remark in a former chapter, that the health of the mind and brain is most apt to give way where the former is intently occupied on a very limited range of objects; for what is this but saying in other words that the health of the mind gives way most readily where a few only of its powers are in constant and excessive activity? On the same principle, the experienced insufficiency of mere intellectual education to improve the moral condition of man is easily explained; for where the intellect alone is exercised and the moral powers are left uncultivated, what else can be rationally expected but that the latter and their organs should become weakened by inaction?

In the sick-room, too, many evils have arisen from overlooking the intimate relation subsisting between cerebral and mental activity. In fevers, in which nervous sensibility is much excited, and tranquillity and repose of mind are almost indispensable to recovery, it is not uncommon to find the attendants indulging in open or whispered conversations, every word of which is calculated to stir up some waking faculty, or give rise to some false impression upon the senses, which may be painfully and hurtfully brooded over in silence by the patient, till the excitement of mind breaks forth in irrepressible delirium, or in wandering thoughts having no relation to the scene or circumstances in which he is placed. The error is thoughtlessly committed by the friends or attendants, under the mistaken belief that so long as no great noise is made, and the conversation is not addressed to the patient himself, and he is not allowed to take any part in it, no harm can ensue, because he makes no active exertion. But a more correct acquaintance with the connection subsisting between the mind and its corporeal organs would at once reveal the hidden danger, and prevent even the most inconsiderate from acting in a way so likely to defeat the best efforts of the physician. From the same mistaken view, it is a common practice with many people to admit visitors into the presence of the sick, even where tranquillity has been most strictly enjoined. The intruders are warned, perhaps "not to speak, but only to look," and no suspicion is entertained that the mere presentment of an object, connected with the patient, it may be, by many old associations, is sure to excite to activity, not only the senses and powers of perception, but many of the strongest feelings and habitual trains of thought. I have seen mischief done in this way by those who would willingly have made any sacrifice for the relief of the sufferer, and who were themselves most distressed on being made aware how much their conduct was really opposed to the fulfilment of their warmest wishes.

From the same disregard of the dependence of the health of the nervous system upon the due exercise of all the powers of the mind, emotional and social as well as intellectual, it was long but most erroneously considered sufficient in the treatment of the insane, to place them in secure confinement, without any provision whatever being made for their occupation or amusement, for the gratification of their affections and moral feelings, or for strengthening their reason by friendly intercourse. And when, in such unnatural circumstances—circumstances often sufficient in themselves to shake the healthiest minds—recoveries were few and far between, the unfortunate result was ignorantly ascribed entirely to the mysterious and intractable nature of the disease, and no effort was made to amend it. At last, however, a brighter day has dawned, and it is beginning to be generally understood, that, in insanity, as in other diseases, the laws which preside over the vital functions continue to operate, and that, during mental derangement as well as sanity, the regulated activity of every bodily organ exercises a great influence upon the health of the brain. As a consequence of this admission, efforts are now made to provide for the insane the means not only of bodily exercise and occupation in the open air, but also of intellectual, moral, and social enjoyment. Severity and neglect are happily laid aside as inconsistent with this purpose; and the unhappy lunatic, formerly controlled by brute force, now finds himself the object of a systematic kindness, and intelligent and active sympathy, the tendency of which is to contribute powerfully towards his recovery, by at once soothing the morbid irritability of his troubled spirit, and securing for him all the enjoyment which he can derive from gratified feelings and affections.

In some lunatic asylums schools have been established, as at Hanwell; and the experiment, though but of recent date in this instance, has been already crowned with success. "Since we commenced in January 1848," says Mr Waite, in the Report for that year, "64 male patients have attended the school; of whom

				Years of age.
5	are above	10	and under	20
19	...	20	...	30
15	...	30	...	40
8	...	40	...	50
7	...	50	...	60
2	...	60	...	70

Of these patients 31 are epileptic, attended with mania; 9 of the number under various stages of imbecility; 20 are insane, subject to periods of excitement; 3 are congenital idiots; and there were 2 recent cases of mania who have been cured, and left the asylum." During the same time, 73 female patients attended the school, under the superintendence of Miss Waite, and were "daily instructed in reading, writing, a variety of lessons on the black board, on natural history, spelling," &c. "The period since the school commenced," says Miss Waite "has been too recent to enable me to offer to your notice many remarkable cases of improvement; but I have seen these heavily afflicted women assemble in the school-room with cheerfulness and ready obedience, proceed to arrange themselves in their accustomed places, and apply themselves with wonderful perseverance and diligence to their several employments; and during the whole time they are present the utmost order and decorum prevail, whilst the silence, unless they are called on to speak, is profound. And during the twelve months the school has been established, I can only remember one instance where it was necessary to request the attendant to remove a patient for violent conduct. On the whole, my teaching has been received by the patients with such apparent pleasure and gratitude, that it has truly lessened whatever labour may attend it, and given me, with your sanction, every encouragement to go on rejoicing."*

In asylums, the object of teaching is not merely to instruct the patients in reading and writing, &c., but chiefly to awaken the intellectual and moral faculties; and it is wonderful to see the results which may thus be produced in the mental condition of even the imbecile and idiotic. "Idiot schools" have been formed in the hospital of Bicêtre at Paris, and there are similar institutions at Highgate, Colchester, and Bath, where idiotic children are received and educated.† In Switzerland, Dr Guggenbühl's training establishment for idiots, near Interlachen, has acquired a high reputation over Europe.* Too much honour cannot be awarded to those who devote their lives to the moral and intellectual elevation of these helpless beings!

Where the patients belong to the educated classes, much benefit may be derived from instruction in natural history, and from lectures on literature, chemistry, or natural philosophy. The disordered mind gradually acquires a new bias; the overwrought faculties are relieved and rested, and the others are gently stimulated to action. But instruction must be blended with amusement; and hence the utility of music and even dancing, of occasional visits to the theatre, and of country excursions. These are resorted to with excellent effect in some of our chief public asylums. In short, there is no reason why an insane patient should be treated on different principles from one labouring under any other malady. The mind, it is true, is deranged, but it is so only through disease of the organs by means of which it acts. When there is inflammation or over-excitement of an organ, we soothe it and give it rest; when it is weak and deficient in vitality, we endeavour, by the judicious use of tonics and exercise, to improve its nutrition, and thus to raise its powers. The treatment of the insane ought to be conducted on precisely the same principles; and mere seclusion in an asylum can no more be accounted proper treatment for disorders of the mind, than imprisonment in the wards of an hospital can be accounted such for diseases of the body.

Keeping in view, then, the independent action of the different faculties, and the relation of each to its own cerebral organ, the first of the *functional* conditions of the health of the brain and nervous system, to which it concerns us to direct our attention, is that which points to *the direct exercise of every faculty and its cerebral organ* as indispensable to its free development and vigorous action. But as this principle is of the highest practical importance, and is habitually lost sight of in moral education and in social life, I cannot refrain from enlarging somewhat further upon it, even at the risk of being tedious.

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* Psychological Journal, vol. ii., p. 427.

† The Highgate and Colchester Asylums are under the patronage of the Queen, and, like the others above referred to, are designed, "not merely to take care of the idiot, but especially, by the skilful and earnest application of the best means in his education, to prepare him, as far as possible, for the duties and enjoyments of life." Such institutions deserve and solicit the liberal support of the wealthy; and any information respecting those at Highgate and Colchester may be obtained from the Rev. Drs Holloway and Reed, the honorary secretaries of the Charity, at 29 Poultry, London.

* See Dr Forbes's "Physician's Holiday," chap. xix.; and "Some Account of Cretinism, and the Institution for its Cure on the Abendberg, near Interlachen, by W. Twining, M.D.;" London, 1843. There is a notice of Dr Twining's work in the British and Foreign Medical Review, vol. xvii., p. 514.

The principle on which I insist is indeed so much in accordance with the dictates of common sense, that it has long been acted upon in some departments of education, not so much from its importance being recognised, as from an almost instinctive perception of its propriety. When we wish, for example, to train the muscles to the graceful and rapid evolutions of fencing, we do not content ourselves with merely giving directions; but our chief attention is employed in making *the muscles themselves* go through the evolutions, till, by frequent repetition and correction, they acquire the requisite quickness and precision of action. In like manner, when we wish to teach music, we do not merely address the understanding and explain the qualities of sounds, but we train the ear to their attentive discrimination, and the hand to the reproduction of the motions which call them into existence. We follow this plan, because the laws of the organism require direct practice, and we feel instinctively that we can succeed only by obeying them. Now, the purely mental faculties, being connected during life with material organs, are subjected to precisely the same laws: consequently, if we wish to improve the reasoning powers, we must exercise them regularly in tracing the causes and relations of things—and, on the same principle, if our aim be to develope the sentiments of Attachment, Benevolence, Justice, or Respect, we must exercise each of them directly and for its own sake, and not content ourselves with teaching precepts, which address themselves to the understanding alone; and which, therefore, may be learned with the greatest accuracy, without necessarily imparting even the smallest increase of vigour to any one of the emotions just named.

Such being the constitution which God has given us, it should never be forgotten, that in education it is the brain, or organ of mind, and not the abstract immaterial principle, which requires cultivation; and that hence *education operates invariably in subjection to the laws of the organism.* In improving the *external* senses, we admit this principle readily enough; but whenever we come to the *internal* faculties of thought and feeling, it is either denied or neglected. With gross inconsistency, we admit that the superior quickness of touch, sight, and hearing, consequent upon judicious exercise, is always referrible to increased facility of action in their appropriate organs; but when we explain, on the same principle, the superior development of the reasoning powers, or the greater warmth of feeling, produced by similar exercise, in the social or moral feelings and other internal faculties, few are inclined to listen to our proposition, or allow to it half the weight or attention which its importance requires, although every fact in philosophy and experience concurs in supporting it. We observe the mental powers of feeling and of thought unfold themselves in infancy and youth, in exact accordance with the progress of the organism; we see them perverted or suspended by the sudden inroad of disease, and as suddenly restored; nay, we sometimes observe every previous acquirement obliterated from the adult mind by fever or by accident, leaving education to be commenced anew, as if it had never been; and yet with all these evidences of the organic influence before us, it is still a novelty in education to propose that the established laws of physiology, as applied to the brain, should be considered as the best and surest guide; and till lately, scarcely a volume could be pointed out in which it is even hinted that these laws have the slightest influence over mental or moral improvement.

In modern education too much is

done by means of books, and too little by trusting to the natural powers of the mind. When books were difficult of access, and knowledge was taught and transmitted orally, a higher effort of attention was excited, the mind worked more vigorously, and retained better and in a more distinct form what it had acquired. With books ever ready at command for reference, the attention is not so alive, and there is less earnest eagerness to seize and retain what is offered to the memory. The mental faculties do not work so vigorously, because no one has the same stimulus to effort. If any thing slip from the memory, it can still be found in the book. In schools this is an evil, and great advantage might be derived from exercising the mind more directly on its immediate objects, and less through the medium of books. Actual and correct ideas would be thus more certainly acquired. This plan is successfully followed to a considerable extent in Stow's Normal Training School in Glasgow and Williams' Secular School in Edinburgh, and is beginning to be acted upon in some other seminaries, but as yet not nearly so much as it ought to be.

The extraordinary mental acquirements of the blind who cannot read, afford a striking proof of the extent to which intellectual cultivation and vigour of mind may be carried by the natural exercise of the faculties without reading. Many examples may be found of the blind arriving at distinction by their attainments in literature, poetry, science, and the practical arts, and displaying in the application of their knowledge a reach and energy of mind which no difficulties could daunt. I need only refer to Milton, Saunderson the mathematician, Blacklock, Metcalf the road-surveyor and engineer, and Holman the blind traveller; to whose names those of many others might be added. James Wilson, author of the *Biography of the Blind*, was himself a remarkable example of the invigorating power of mental exercise under an adequate stimulus. He lost his sight at seven years of age, and was subjected to great disadvantages from poverty and want of the means of education. Having naturally, however, no small share of talent, and a strong thirst for knowledge, he ultimately succeeded in greatly improving his mind, and raising himself to a higher station. In allusion to the effects of the mental discipline rendered necessary by the loss of sight, he says: "Memory has often been compared to a well-constructed arch, on which the more weight is laid the stronger it becomes. This I found to be the case with mine, for the more I committed to it, the more I found it capable of receiving and retaining." And again: "I was now able to appreciate the pleasures of memory in a superior degree, for I knew the names, stations, and admirals, of almost all the ships in the navy, and was also acquainted with the number, facing, and name of every regiment in the army, according to the respective towns, cities, or shires, from which they were raised; and thus served as an army and navy list for the poor of the neighbourhood." (P. xxxii.) "At a later period of life," he says, "to a few select friends who wished to prove my knowledge of English history, I repeated, to their entire satisfaction, an epitome of the history of England, from the Norman Conquest till the peace in 1783, including invasions, conspiracies, insurrections, and revolutions; the names of all the kings and queens, the year of their accession, the length of their reigns, and the affinity each had to his predecessor, together with the names and characters of all the great statesmen, heroes, philosophers, and poets who flourished in the different reigns. In consequence of this and similar rehearsals, I was termed a 'Walking Encyclopedia;' to others my knowledge in such circumstances appeared a prodigy, but to myself it proved a source of consolation, and beguiled many a weary hour." (P. lv.) The extraordinary facility with which actors store up their parts is another example of the invigorating influence of healthy active exertion of mind. It strengthens, while indolent inattentive exertion only weakens.

The great error of the present mode of education consists in its not discriminating between the different powers of different individuals. "There are as many streams of knowledge," happily observes a recent writer, "as there are mental faculties;" and these faculties vary in strength and quickness. Hence, the cultivation necessary for their due exercise in one individual will be too much in another; and thus, while in one case they acquire increased development from duly proportioned exercise, in another they are worn out and overwhelmed. Herein lies the folly of educating all alike. "Can anything be conceived more irksome to a boy of slow apprehension," asks Dr Bush,* "than the very first lesson he is taught at school—the definition of the parts of speech—the dry grammatical construction of language? Can anything be conceived more *exasperating*, if, in addition to his natural dulness, he possess a highly nervous susceptibility, and perhaps some vivacious sentiments, than the repetition of a task he can neither understand, nor perhaps has even verbal memory enough to repeat to the satisfaction of his teacher? Can punishment elicit from one of such a conformation an amount of intelligence which he really does not possess? And yet it is expected, because it happens to be the custom of the school, and in the usual order of teachers. In all such cases, there can be no doubt in the mind of any impartial person, where the error lies—it is in the system, and not in the pupil; it is in the scholastic pride, which being ignorant of, or disregarding, the laws of nature, would supersede them by its own artificial rules—it is in the folly, or something worse than folly, of sacrificing the moral interests of the individual to a vain attempt at forcing him to an intellectual position which nature has denied him. . . . It is by dividing the burden equally among the faculties, imposing upon none more than it can safely and agreeably bear, and by keeping some even in a state of repose, that so much may be accomplished in educating the weak-minded, and bringing them gradually to the possession of that kind of knowledge which, though it may not make them eminent in literature, will at least make them competent for the useful and respectable business of life."

In some respects the adult labourer may be compared with the dull schoolboy. His mental faculties are obtuse from want of exercise. A hewer of wood and drawer of water, his bones and muscles are strained by constant work, while his exhausted energies crave the excitement of brutal sports and recreations, and too often demand imperiously the stimulus of alcoholic drinks. On the weekly day of rest it is in vain to solicit his attention to abstract theological discourses, or endeavour to excite in him that devotional fervour, which only those in whom the nervous system is naturally, or from training, susceptible of ready excitement are apt to experience. "For the profitable devotion of one entire day to moral and intellectual pursuits, there must have been previous training for them. Where there has been no previous training, where large masses of the population have been suffered to grow up in ignorance of the first elements of human knowledge, the *power* of continuous thought is wanting; animal instincts predominate, and animal gratifications can alone supply the void made by the cessation of mechanical employment. With such classes there can be no medium between the out-of-door pastimes, which we have rendered illegal, and the drinking and gambling of the whisky-shops of Scotland, and the beer-shops and public-houses of England. Those who would legislate for man, other than he is, must answer for the consequences to his Maker."* Let us then hope that the day is not far distant when all our religious instructors will make the discovery, already reached by most thinking and well-informed men, that the reputed moral superiority of the inhabitants of Britain over their Continental neighbours is but the figment of national self-conceit,—unless, indeed, in-door drunkenness and dissipation be more commendable than recreation in public parks, or the wholesome pleasures derivable from elegant literature, works of art, music, and social meetings. Some of the Continental nations, and the United States of America, by the superior education afforded to the people, are fast outrunning us in the race of true civilization; and unless a well-organised plan of national education be speedily introduced into England, the consequences to the wellbeing of the kingdom cannot fail to be disastrous.

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* Psychological Journal, No. vii., p. 447-453.

* Westminster Review, Oct. 1850.

Were a general acquaintance with the laws of the organism to be held as an indispensable part of a liberal education, we should then be able to inculcate, with tenfold force and success, the necessity of actively exercising every faculty, whether of thought, feeling, or motion, directly *on its own objects,* and at once to explode the mistake of supposing that any organ or function may be efficiently exercised through the medium of another, and that, to produce high moral feeling, it is sufficient to address ourselves to the intellect alone. The merest savage, following the footsteps of Nature, would pity the philosopher who should seriously assure him that, to cultivate acuteness of hearing or of vision, it was sufficient to be told how to listen or to look. The savage goes more directly and surely to work. If he wants physical strength, agility, and swiftness of foot, he sets himself to develope the muscular system of his child by ample muscular exercise, by constant repetition of the movements and acts he wishes him to perform, and by causing him to run, to leap, or to swim; and he rests in the well-founded hope of accomplishing his purpose. Following the same rule when he seeks acuteness of hearing, he does not merely tell his child how to listen, but he lays him with his ear to the ground, and ches him, by practice, to distinguish the qualities of sounds. If he wishes him to excel in hunting, in fishing, in lying in ambush, or in scenting the approach of an enemy, he expects to be successful only in proportion as he finds occasion to employ him in the practice of these pursuits. If he wishes to inculcate courage in battle, contempt of pain, endurance of fatigue, obedience to chiefs, or revenge upon enemies, he does not satisfy himself with mere precept, but resorts at once to *practice*, and by subjecting his child to hardship and privations, exposing him to danger, and exacting from him unhesitating submission to authority, he succeeds in eliciting all the qualities essential for the circumstances under which he lives, and without the possession of which he would neither be safe from his enemies nor respected by his friends.

With this experience before our eyes, then, let *us*, who pretend to superior wisdom and civilization, shew ourselves also consistent, and ready to receive instruction from whatever quarter it may come. As God has given us bones, muscles, blood-vessels, and nerves, for the purpose of being used, let us not despise the gift, but consent at once to turn them to account, and to reap health and vigour as the reward which He has associated with moderate labour. As He has given us lungs to breathe with, and blood to circulate, let us abandon the folly of shutting ourselves up with so little intermission, engaged in motionless study and other sedentary occupations,—and consent to inhale copiously and freely that wholesome atmosphere which His benevolence has spread around us. As He has given us appetites and organs of digestion, let us profit by His bounty, and earn their enjoyment by healthful exercise. As He has given us a moral and a social nature, which is invigorated by activity and impaired by solitude and restraint, let us cultivate good feeling, and act towards each other on principles of kindness, justice, forbearance, and mutual assistance; and as He has given us intellect, let us exercise it in seeking knowledge of His works and of His laws, and in tracing out the relation in which we stand towards Him, towards our fellow-men, and towards the various objects of the external world: and, in perfect faith and sincerity, let us rely upon His promise, that, in so doing, we shall have a rich reward—a reward a thousand times more pure, more permanent, and more delightful, than we can ever hope to experience in following our own blind devices, regardless of His will and intentions towards us.*

So little, however, are even educated men familiar with the influence and laws of the organism, that even in many of our best-directed establishments, as well as in private families, cultivation is still in a great measure confined to the intellect alone; and the *direct* exercise and training of the moral and religious sentiments and affections are rarely thought of as essential to their full and vigorous development. Moral precepts are, no doubt, offered in abundance; but these, as we have seen, address themselves chiefly to the intellect. We must not be satisfied with merely exclaiming, "Be kind, just, and affectionate," when perhaps at the very moment we are counteracting the effect of the advice by our own opposite conduct. "*She told me not to lie,*" said Guy Rivers, in speaking of his mother, "*and she set me the example herself by frequently deceiving my father and teaching me to disobey and deceive him.*" Conduct like this is more common in real life than is supposed, although generally less flagrant in degree. Parents, indeed, too often forget that the sentiments *feel* and *do not reason*, and that, consequently, even a stupid child may, by the instinctive operation of its moral nature, at once detect and revolt at the immorality of practices, the true character of which its *reason* is unable to penetrate or expose. It is one of the most effectual methods of cultivating and exciting the moral sentiments in children, to set before them the manifestations of these in our habitual conduct; and we should be most careful never to practise before them that which we do not wish them to imitate. If we first chide a child for seeking to indulge its sense of taste, and attempt to impress it with the impropriety of cultivating the animal appetites by devouring sweetmeats and delicacies,—but, on sitting down to dinner the next moment, begin to expatiate with delight on the excellence, richness, and flavour of the dishes of which *we* are partaking, what can the child be expected to think or to do? Seeing practice and precept thus set in opposition, what weight can it possibly attach to the mere verbal injunction? Again, what improving influence can that parent exert over the moral conduct of his child, who, verbally recommending kindness, openness, and justice, *tricks* the child into confession of faults, and then basely punishes it, having previously promised forgiveness? And how is openness best encouraged—by practising it in conduct, or by neglecting it in practice but praising it in words? Is it to be cultivated by thrusting suspicions in the face of honest intentions? Or what kind of moral education is that which says, *Do as I bid you, and I will give you sweetmeats or money, or I will tell your mama how good you were;* holding out gratifications to the lowest and most selfish propensities as the motives to moral conduct! Did space permit I might pursue the whole round of moral and religious duties, and ask similar questions in regard to each. But it is needless. These examples will suffice; and I give them not as generally applicable, but simply as individual instances which have come within the sphere of my own knowledge, and which bear directly upon the principle under discussion.

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* Those of my readers who wish to pursue the inquiry, and to trace the relations in which Man stands to his Creator, to his fellow-creatures, and to the external world, will find a clear and comprehensive guide in a small volume, entitled "The Constitution of Man considered in Relation to External Objects, by George Combe." In this work, of which upwards of 90,000 copies have been disseminated within the last twenty years, a general view is taken of the human constitution, and of the laws which regulate the organic, moral, and intellectual nature of man. The sources of most of the evils which afflict the human family are successfully traced to disregard of those laws, and shewn to be, to a great extent, within our own control; so that practical usefulness, and not mere speculation, is the characteristic of the volume.

In the practical training of the young, it is of consequence to keep in mind that the moral sentiments, in common with the intellect, are dependent on the organism for their means of activity during life, and consequently are more successfully cultivated by being habitually employed in regulating the every-day affairs of life, than by waiting for great occasions on which they may be exercised with unusual vigour. Benevolence, no doubt, is vividly excited by the aspect of great misery and destitution, and impels strongly to the relief of the suffering object; but this is not its most common or its most useful field. In ordinary life, it finds ample scope in charity to our neighbours, and in contributing to the happiness of our family circle, and of our associates and dependents. Benevolence is much better occupied in adding a gleam of enjoyment, in removing little sources of irritation, in promoting concord among relatives, and in other kind offices of a similar nature, than in giving alms indiscriminately to all who demand them, or even in relieving occasional distress, where this is held, as it too often is, to dispense with all obligation to habitual forbearance and Christian good-will in the private relations of life. But how little is this most important faculty directly attended to or cultivated, in the way we see done with the faculties necessary for the practice of drawing or music, which, by incessant exercise, procured at a great sacrifice of time, money, and labour, are brought into such a state of activity as ever after to enable their possessors to derive delight from their exercise, where the talents are possessed in any considerable degree! And what might we not expect from the systematic training of the higher sentiments on a similar plan, in improving society and exalting the happiness of the race! But it is evident that the objects of benevolence are our fellow-creatures; and consequently, if we restrict our intercourse and our sympathies to the limits of our own drawing-rooms, and take no interest in the progress of the race or of the individuals composing it, we leave our best faculties in abeyance, and reap the reward of bodily debility, weariness, and monotony of mind.

Conscientiousness is another moral faculty that requires direct cultivation, and that rarely receives it. It holds the balance between man and man, and is excited by the presentment of any difference of right between individuals, of any injustice, or of any temptation offered by the other faculties, which may lead us to encroach on the rights of other men. It gives a strong sense of duty, in conformity with which it is agreeable to act, but which it is painful and injurious to oppose. It gives weight and force to the impulses of the other sentiments, and, joined with enlightened intellect and the feeling of devotion, gives that faith in the beneficence and equity of the Deity, and in the unchangingness of His laws, which forms the strongest encouragement to virtuous conduct and temporary self-denial. But seclusion and privacy afford no scope for such an exercise of conscientiousness; and here we find an additional proof that Providence intended every one to live in society, engage in the active duties of life, and act justly amidst the conflicting interests of others!

I need not pursue this exposition in detail. The preceding illustrations will suffice to explain the *principle;* and to exceed this limit would withdraw attention too much from the matters more directly before us.

For the same reason, that every faculty ought to be exercised directly upon its own objects, the exclusive use of book-education as a means of conveying instruction is manifestly unnatural as well as inefficient. If allowed to handle and examine a new object, a child will pursue the investigation with pleasure, and in five minutes will acquire a more correct knowledge than by a whole week's reading about its qualities without seeing it. In the one instance, his perceptive powers are stimulated by the actual presence of the qualities of which they are destined to take cognizance; while, in the other, they are roused only through the imperfect medium of artificial language, and the child has to *create* the object in his own mind before he can take notice of its qualities. When we recollect the different ideas which the same written language suggests to different *mature* minds, we may form some conception of the impossibility of a child making much progress in this way, and of the weariness and ennui which the thankless effort must always induce; and yet at the present day, in nineteen out of twenty schools, all the knowledge that is offered is through the medium of books and language alone.

It is well remarked by Mr Duppa, in his excellent little work on the education of the peasantry in England, that "it is the habit of accurately observing the actual nature of objects, as perceivable by the senses, and distinctly marking their differences, which in after life renders a man intelligent and judicious. There are few whose natural faculties are so dull as to be unable to perceive a distinction when pointed out to them, or when their notice is directed towards it,—for instance, that one thing is long, another short; that one thing is round, another flat, one green, and another black. But how few are there who, when minutely questioned, can give a clear or circumstantial description of any object they have been conversant with, or in what particular that object differs from another! And why is this? Because they have not the habit of accurate observation of things; and they have not that habit, *because in modern education a child's observation at the moment when all is new, and observation most active, is wilfully drawn away from things to the signs of things; and the boy who might easily have been made to distinguish the nature and properties of the different objects around him, has only learned to distinguish one letter from another.*" (P. 27.)

It is but another proof of the harmony of design in all the works of the Creator, that this method of directly cultivating the observing powers cannot be adequately fulfilled without a certain amount of muscular exertion and of daily exposure to the open air, in going about to collect and examine the varied objects of interest with which creation abounds. In other words, we cannot benefit the perceptive faculties, without at the same time benefiting the muscular system and the organs of respiration, circulation, and digestion; and this grand recommendation in the eye of reason,—pursuing study in the field of nature, instead of in books alone,—is actually, though not avowedly, the circumstance which retards its adoption in ordinary education. To take the scholar out of the school-room to look at the works of God is thought to be encouraging idleness and a love of pleasure, and therefore such a course is not by any means to be thought of!

What, therefore, is wanted is a system of education which shall not only give full play to the intellectual faculties, but also make ample provision for the direct exercise of the physical and moral powers and domestic affections. While we cultivate the intellect, let us never forget that our moral nature is of still greater importance in fitting us for the duties of life. And while we cherish both the intellectual and moral faculties, let us also bear in mind that both act by means of a physical organism, the well-being of which is indispensable to their health and soundness, and to our happiness; and that, therefore, due provision must be made for its active employment either in useful labour or in daily exercise. The details of such a system do not fall under the scope of a work like this; and having, in the last three chapters of my *Treatise on the Physiological and Moral Management of Infancy*, entered pretty fully into the subject, I think it unnecessary to proceed here beyond the foregoing exposition of the general principle.*

During infirm health, a serious obstacle to entering upon the regular exertion here recommended is often present, and arises from a feeling in the patient, against which he cannot be too much on his guard. Where the nervous system is weak, and where it of course requires most to be strengthened, there is often a retiring sensitiveness of disposition, leading its possessor rather to avoid than to seek intercourse with society. Feeling the irksomeness of present exertion, the nervous invalid is apt to form the secret resolution to live in solitude *till the mind shall become stronger*, and then to seek society when it will no longer be a burden. Unhappily, however, this feeling leads only to delusion, and the wished for result becomes every day more distant the longer retirement and indolence are persevered in. *It is by activity, and not by repose, that strength is to be acquired.* We do not expect to increase bodily strength by lying in bed, but by stirring about; and, in like manner, we shall never succeed in strengthening the nervous system by indulging in solitude and mental indolence. Many are led astray by the false expectation of acquiring strength without using the natural means by which alone strength can be procured.

These remarks may shew how necessary it is that teachers generally, and especially those entrusted with the care of the weak-minded, should be thoroughly acquainted with the laws of physiology and hygiène. "It is obvious," says Dr Bush, in speaking of the education of children of feeble brains, "that they whose profession and daily business it is to observe and treat those organs and faculties when diseased, must best know and most duly weigh their capabilities and powers of endurance when weak; we say that to such men, combining the physician with the instructor, should the work be committed,—to such men should be given the power of ordering the quantity, the quality, the method, the season, and, indeed, every circumstance connected with the important duty of educating a weak-minded yet immortal being. Such men as these alone can fully appreciate the deplorable effects of over-education in weak subjects, and they alone are capable of carrying into successful practice the hygiènic system now proposed. Such men, conversant with these facts, would at once join in the recommendation of making green fields the chief school-room, and nature the chief lesson-book for such weak minds; and would study to make the way to knowledge easy and pleasant, by means of familiar colloquy, kind sympathy, and good examples. Such men, conversant with the various faculties of the mind, would best know how to discriminate between those which may be cultivated with impunity, and made the instrument of strengthening and developing the others. Such men alone can know when to desist and when to persist in their attempts to instruct."*

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* In the "Reports on the Training of Pauper Children," submitted to the Secretary of State by the Poor Law Commissioners in 1841, the reader will find a vast amount of evidence, of the most instructive kind, illustrative of the principles inculcated in these pages. The whole of it being derived from actual and extensive experience in intellectual and moral training, it possesses a force and value which no unprejudiced and intelligent mind can resist. As regards the prevention of crime, and the general improvement of the poor and working classes in character and social comfort, I consider these Reports to be the most important contribution which the public has received for many years. In Mr Simpson's able work on "The Philosophy of Education," the reader will find an eloquent exposition of the general subject of popular education. The following works also may be consulted with advantage:—The Training System of Education, Religious, Intellectual, and Moral, as established in the Glasgow Normal Training Seminary, by David Stow, Esq. (7th edition, 1847.) Warne's Phrenology in the Family; Bray's Education of the Feelings; Wilderspin on Infant Education; Dr Mayo's Lessons on Objects, as given in a Pestalozzian School at Cheam, Surrey (London, 1831); and Madame de Wahl's Practical Hints on the Moral, Mental, and Physical Training of Girls at School (London, 1847.)

Another practical principle immediately connected with the proper exercise of the mental faculties and their cerebral organs, and the influence of which has not been sufficiently appreciated in educational management, is that which inculcates judicious *repetition* as indispensable to obtaining *durable* results. The manner in which the repetition of a functional act operates in improving the condition of the organ, may be understood from the explanation formerly given of the influence of exercise upon nutrition (see p. 112). At present it will be sufficient to remark, that to induce strength and facility of action in the organs of the mind, *practice*, or the repetition of the effort, is as essential as it is in the organs of motion. The idea or feeling must not only be communicated, but it must be reproduced and represented in different forms, till all the faculties concerned in understanding it come to work efficiently together in the conception of it, and till a sufficient impression be made upon the organ of mind for the latter to retain it. This is, in truth, the reason why in some parts of this treatise I have ventured upon an extent of repetition, which I should have been the first to condemn and avoid had the subjects been less important, or more familiar to the reader. From overlooking this necessity of repetition, we often blame servants for not doing a thing every day, because they were *once* told to do so. The organic laws, however, teach us that we are presumptuous in expecting the formation of a habit from a single act, and that we must produce the associated activity of the requisite faculties many times before the result will certainly follow; just as we must repeat many times the movements in dancing or skating, before we become master of them. In like manner, we find, on turning to a new subject, that however well we may understand it by one perusal, we do not fully master it, except by dwelling upon it again and again. Repetition is, in fact, the principle by which the division of labour, so well understood in England, leads to such admirable perfection of work where practical skill, neatness of hand, or high finish, is required; and in the rapid solution of complicated arithmetical questions in many of our common schools, we witness its effects in the operations of mind, quite as remarkably as in those belonging to the mechanical arts.

Repetition is thus necessary to make a durable impression on the brain; and, according to this principle, it follows, that, in learning a language or science, six successive months of application will be more effectual in fixing it in the mind, and making it a part of its furniture, than double or triple the time, if the lessons are interrupted by long intervals of vacation. Hence, it is a great error to begin any study, and then break off to *finish* at a later period. The *ennui* is thus doubled, and the success greatly diminished. The best way is to begin at the proper age, and to persevere till the object is attained. This accustoms the mind to sound exertion, and not to *fits* of attention.

In physical education, we are quite alive to the advantages of repetition and practice. We know that if practice in dancing, fencing, skating, and riding, be persevered in for a sufficient length of time to give the muscles the requisite promptitude and harmony of action, the power will be ever afterwards retained, although little called into use; whereas, if we stop short of this point, we may reiterate practice by fits and starts, without any proportionate advancement. The same principle applies equally to the moral and intellectual powers, because these operate by means of their appropriate organs.

The necessity of being in private what we wish to appear in public, springs from the same rule. If we wish to be polite, just, kind, and sociable, we must habitually act under the influence of the corresponding sentiments in the domestic circle and in every-day life, as well as in the company of strangers and on great occasions. It is the daily practice which gives ready activity to the sentiments, and marks the character. If we indulge in vulgarities of speech and behaviour at home, and put on politeness merely for the reception of strangers, our rudeness will shine through the mask which is intended to hide it; because the habitual association to which the organs and faculties have been accustomed cannot thus be controlled. As well may we hope to excel in elegant and graceful dancing, by the daily practice of every awkward attitude. In the one case, as in the other, the organs must not only be associated in action by the command of the will, but also be habituated to the association by the frequency of the practice; a fact which exposes the ignorant folly of those parents who habitually act with rudeness and caprice towards their children, and then chide them for unpolite behaviour towards strangers.

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* Pyschological Journal, No. vii., p. 452.

The same principle, of repetition being necessary to make a durable impression on the brain and constitute a mental habit, also explains the manner in which natural endowments are modified by external situation, and how the gradual progress of civilization and the improvement of the human race are effected. The passage from barbarism to civilization is a slow and gradual process, continued almost imperceptibly through the course of many generations, and evidently dependent on the improvement occasioned in the quality, size, and form of the brain by continued cultivation during a succession of ages. How slow this change may be, and yet how it may ultimately be effected, will appear from the following remarkable observations by Mr Darwin, which, because of their important bearing on this point, we quote entire.

"I will conclude my description of the natural history of these islands" (the Galapagos Archipelago), says this eminent naturalist, "by giving an account of the extreme tameness of the birds.

"This disposition is common to all the terrestrial species; namely, to the mocking thrushes, the finches, wrens, tyrant-fly-catchers, the dove, and carrion-buzzard. All of them often approached sufficiently near to be killed with a switch, and sometimes, as I myself tried, with a cap or hat. A gun is here almost superfluous; for with the muzzle I pushed a hawk off the branch of a tree. One day, whilst lying down, a mocking-thrush alighted on the edge of a pitcher, made of the shell of a tortoise, which I held in my hand, and began very quietly to sip the water; it allowed me to lift it from the ground whilst seated on the vessel; I often tried and nearly succeeded in catching these birds by their legs. Formerly the birds appear to have been much tamer than at present. Cowley (in the year 1684) says that the 'turtle doves were so tame that they would often alight upon our hats and arms, so that we could take them alive: they not fearing man, until such time as some of our company did fire at them, whereby they were rendered more shy.' Dampier also, in the same year, says that a man in a morning's walk might kill six or seven dozen of these doves. At present, although certainly very tame, they do not alight on people's arms, nor do they suffer themselves to be killed in such large numbers. It is surprising that they have not become wilder; for these islands during the last hundred and fifty years have been frequently visited by bucaniers and whalers; and the sailors, wandering through the woods in search of tortoises, always take cruel delight in knocking down the little birds.

"These birds, although now still persecuted, do not readily become wild; in Charles Island, which had been colonized about six years, I saw a boy sitting by a well with a switch in his hand, with which he killed the doves and finches as they came to drink. He had already procured a little heap of them for his dinner; and he said he had been constantly in the habit of waiting by the well for the same purpose. It would appear that the birds of this Archipelago, not having as yet learnt that man is a more dangerous animal than the tortoise or the amblyrhynchus, disregard him, in the same manner as in England shy birds, such as magpies, disregard the cows and horses grazing in our fields.

"The Falkland Islands offer a second instance of birds with a similar disposition. The extraordinary tameness of the little opetiorhynchus has been remarked by Pernety, Lesson, and other voyagers. It is not, however, peculiar to that bird; the polyborus, snipe, upland and lowland goose, thrush, bunting, and even some true hawks, are all more or less tame. As the birds are as tame there, where foxes, hawks, and owls occur, we may infer that the absence of all rapacious animals at the Galapagos, is not the cause of their tameness here. The upland geese at the Falklands shew, by the precaution they take in building on the islets, that they are aware of their danger from the foxes; but they are not by this rendered wild towards man. The tameness of the birds, especially of the water fowl, is strongly contrasted with the habits of the same species in Terra del Fuego, where for ages past they have been persecuted by the wild inhabitants. In the Falklands, the sportsman may sometimes kill more of the upland geese in one day than he can carry home; whereas, in Terra del Fuego, it is nearly as difficult to kill one as it is in England to shoot the common wild goose. In the time of Pernety (1763), all the birds there appear to have been much tamer than at present; he states that the opetiorhynchus would almost perch on his fingers, and that with a wand he killed ten in half an hour. At that period the birds must have been about as tame as they are now at the Galapagos. They appear to have learnt caution more slowly at these latter islands than at the Falklands, where they have had proportionate means of experience; for besides frequent visits from vessels, those islands have at intervals been colonized during the whole period. Even formerly, when all birds were so tame, it was impossible, by Pernety's account, to kill the black-necked swan—a bird of passage which probably brought with it the wisdom learnt in foreign countries.

"I may add that, according to Du Bois, all the birds at Bourbon in 1571–72, with the exception of the flamingoes and geese, were so extremely tame, that they could he caught by the hand, or killed in any number with a stick. Again, at Tristan d'Acunha in the Atlantic, Carmichael states that the only two land-birds, a thrush and a bunting, were 'so tame as to suffer themselves to be caught with a hand-net.' From these several facts we may, I think, conclude, first, that the wildness of birds with regard to man is a particular instinct directed against *him*, and not dependent on any general degree of caution arising from sources of danger; secondly, that it is not acquired by individual birds in a short time, even when much persecuted; but that in the course of successive generations it becomes hereditary. With domesticated animals we are accustomed to see new mental habits or instincts acquired and rendered hereditary; but with animals in a state of nature it must always be most difficult to discover instances of acquired hereditary knowledge. In regard to the wildness of birds towards man, there is no way of accounting for it, except as an inherited habit; comparatively few young birds, in any one year, have been injured by man in England, yet almost all, even nestlings, are afraid of him: many individuals, on the other hand, both at Galapagos and at the Falklands, have been pursued and injured by man, but yet have not learned a salutary dread of him. We may infer from these facts, what havoc the introduction of any new beast of prey must cause in a country, before the instincts of the indigenous inhabitants have become adapted to the stranger's craft or power."*

From these facts we learn also, by analogy, how slowly the intellectual and moral development of abased human races must proceed, and how many ages must elapse before the savage native of Australia can attain the degree of civilization at present characteristic of Europe generally. In a minor degree the same remark is applicable to the different races of civilized nations. Long-continued culture has been highly influential in raising the Saxon race above the Celtic: but there seems to be nothing inherent in the brain of the Celt to prevent it from reaching, in the course of ages, the same degree of development, and as good quality, as the Saxon brain. But the education of a single generation is not sufficient to raise the national standard; the work must be continued through a succession of ages. That class which for generation after generation has been employing the muscular system only, cannot be supposed to have attained a cerebral development equal to that of the educated classes. Accordingly, Professor Owen, some years ago, found that the brain of the adult Irish labourer does not weigh more than the average brain of a youth of fourteen in the educated classes; and we have little doubt that extended observations would give the same result. This eminent physiologist, moreover, confesses his ignorance of any modification of form or size in the brain of the negro, that would support an inference that the Ethiopian race would not profit by the same influences, favouring mental and moral improvement, which have tended to elevate the primitively barbarous white races of men.*

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* Darwin's Journal of a Naturalist, p. 398–401.

Sir Charles Lyell, by whom these facts are stated, mentions also that in the Boston schools the white and black children are educated separately, not from an indulgence in anti-negro feelings, but because it is found that in this way both races may be brought on faster. "Up to the age of fourteen the black children advance as fast as the whites; but from that age, unless there be an admixture of white blood, it becomes, in most instances, extremely difficult to carry them forward. That the half-breeds should be intermediate between the two parent stocks, and that the coloured race should therefore gain in mental capacity in proportion as it approximates in physical organization to the whites, seems natural; and yet it is a wonderful fact, psychologically considered, that we should be able to trace the phenomena of hybridity even into the world of intellect and reason."* But this is no isolated fact. Throughout the whole animal kingdom we find mental qualities equally hereditary with bodily qualities, and for this simple reason, that the character of the mind is dependent on the condition of the bodily organs. The offspring of horses which have been trained in the circus shew a natural disposition to learn the feats performed by their parents; while, on the other hand, it is almost impossible to break the immediate descendants of the wild horse.†

"No one," says Dr Carpenter, "who has had sufficient opportunities of observation, can doubt that the intellectual faculties which have been developed by cultivation, are generally transmitted to the offspring in an improved state; so that the descendant of a line of educated ancestors will probably have a much higher capacity for instruction than the child that springs from an illiterate race."‡ In reference to this observation, a medical journalist exclaims—"How wide a field for discussion and for action does this consideration present! How gravely do the spread of education and the *science* of intermarriage address themselves to the attention of the philanthropist and the legislator! The fruits of care and culture are not confined to the well-being of a single individual: they bear within them the blessings of increase, and multiply tenfold with each succeeding generation."*

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* Second Visit to the United States, by Sir Charles Lyell, vol. i., p. 129.

* Loc. cit.

† For much information on hereditary influence, see Traité de L'Hérédité Naturelle. Par le Dr P. Lucas. Paris, 1850.

‡ Principles of General and Comparative Physiology, p. 512.

It is only by long-continued culture, therefore, that the cerebral development, and consequently the mental and moral attributes of a race, can be changed; and hence we may learn the folly of suddenly casting upon a people, by means of violent political revolution, the fulfilment of duties to which they have not been gradually trained. Writing in 1824, Sir Thomas Munro said: "I shall never review my own proceedings, because they can have no sensible effect in my time or for many years after: for it is the nature of measures calculated for improvement to be slow in their operations. When I read, as I sometimes do, of a measure by which a large province has been suddenly improved, or a race of semi-barbarians civilized almost to Quakerism, I throw away the book." That the form and size of the brain are changed by mental culture, is indicated by numerous facts to which I have elsewhere directed attention,† as well as by the few observations which have yet been made on the crania found in tumuli or other ancient places of interment.‡

In the individuals of a race we see more plainly the influence of education and habit in changing or forming character, than in the race as a body. Place, for example, a child of *average* propensities, sentiments, and intellect, among a class of people—such as thieves—in whom the selfish faculties are exclusively exercised; by whom gain is worshipped as the end of life, and cunning and cheating as the means; and among whom is never heard one word of disapprobation or moral indignation against either crime or selfishness; and the lower faculties of this child will be exclusively exercised and increased in strength, while the higher will be left unemployed and become weak. It will consequently not only act as those around it do, but insensibly grow up resembling them in disposition and character; because, by the law of repetition, the organs of the selfish qualities will have acquired proportionally greater aptitude and vigour, just as do the muscles of the fencer or dancer. But suppose the same individual placed *from infancy* in the society of a highly moral and intellectual circle; the moral faculties will then be habitually excited, and their organs invigorated by repetition, till a greater aptitude, or, in other words, a higher moral character, will be formed. There are, of course, limits set to this modification by the natural endowments of the individual; but where the original dispositions are not strongly marked, the range is still a wide one.

In carrying repetition into effect, the times and circumstances under which it should be practised also deserve the most serious consideration. On these I shall accordingly offer a few remarks.

It seems to be a law of the animal economy, that two classes of functions cannot be habitually in exalted action at the same time, without one or other, or both, sooner or later sustaining injury. Hence the important rule, *never to enter upon continued mental exertion, or to rouse deep feeling, immediately after a full meal*, as the activity of the brain is sure to interfere with that of the stomach, and disorder its functions. Even in a perfectly healthy person, unwelcome news, sudden anxiety, or mental excitement, occurring after eating, will put an entire stop to digestion, and cause the stomach to loathe at the sight of food. In accordance with this, we learn by experience, that the worst forms of indigestion and nervous depression are those which arise from excessive application of mind or turmoil of feeling, conjoined with unrestrained indulgence in the pleasures of the table.

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* Medico-Chirurgical Review, April 1843, p. 450.

† Phrenological Journal, x. 414.

‡ See The Archæology and Prehistoric Annals of Scotland, by Daniel Wilson, chap. ix., on the "Crania of Tumuli." Mr Wilson deserves much credit for the laborious and accurate manner in which he has collected and arranged the scanty materials of this chapter; and it is to be hoped that increased attention will be paid to the subject by archæologists in future.

In such circumstances, the stomach and brain react upon and disturb each other, till all the horrors of nervous disease supervene, and render life miserable. Literary men and hard students know this fact from sad experience; but, as they are not aware of the incompatibility of the two processes of active thinking and active digestion going on at the same time, it is extremely difficult to give them a sense of their danger, and to convince them that an hour or an hour and a half after a meal is more profitably spent in easy relaxation than in the labour of composition. As regards the lower animals, indeed, we are careful enough to observe this organic law; for we do not allow our horses or dogs to be actively exercised till digestion is in some degree advanced.

It may be said that mechanics, labourers, and others, hurry away to work immediately after meals without any apparent injury; and that, in the United States, the practice of hastily swallowing dinner and instantly returning to business is almost universal. My answer to this objection is simply, that experience proves the fact that digestion goes on better when exertion is refrained from and repose is enjoyed; and that the tendency to sleep and inactivity which besets most animals after a full meal, shews repose to be, in such circumstances, the intention of Nature. It must be observed, also, that the bad effects of immediate exertion are not among those which ensue instantly, or are felt from day to day. They may shew themselves only at the end of months or years, when the influence has, as it were, accumulated by repetition. Although, therefore, the system possesses a certain power of resistance, and many persons seem to escape even for years, it cannot be doubted that opposition to the law of nature will eventually prove injurious. The extreme prevalence of dyspeptic complaints and of insanity among the Americans, is doubtless partly owing to the very practice which is supposed by some to be harmless to them. Dr Caldwell, who has devoted much time and talent to the diffusion of sound knowledge and the improvement of the race, and whose opportunities of observation have been very extensive, expressly mentions that "dyspepsia and madness prevail more extensively in the United States than among the people of any other nation. Of the amount of our dyspeptics," says he, "no estimate can be formed; but IT IS IMMENSE. Whether we inquire into cities, towns, villages, or country places, among the rich, the poor, or those in moderate circumstances, we find dyspepsia more or less prevalent throughout the land."* It is clear from this testimony (which is confirmed by many other observers) that the people of the United States form no exception to the general law of nature, and that they *do* suffer for their hurried eating and neglect of repose after meals.†

The *time best adapted for mental exertion* falls next to be considered. Nature has allotted the darkness of night for repose, and for the restoration, by sleep, of the exhausted energies of mind and body. If study or composition be ardently engaged in towards that period of the day, the increased action in the brain which always accompanies activity of mind requires a long time to subside; and, if the student be at all of an irritable habit of body, he will be sleepless for hours after going to bed, or perhaps be tormented by unpleasant dreams. If, notwithstanding, the practice be continued, the want of refreshing repose will ultimately induce a state of morbid irritability of the nervous system, not far distant from insanity. It is, therefore, of great advantage to engage in severer studies early in the day, and devote two or three of the hours which precede bed-time, to lighter reading, music, or amusing conversation. The vascular excitement previously induced in the head by study has then time to subside, and sound refreshing sleep is much more certainly obtained. This rule is of great consequence to those who are obliged to undergo much mental labour; and it will be found that many of our most prolific writers,—those especially who write much and yet preserve their health,—have either from knowledge or inclination devoted their mornings to study and their evenings to relaxation, and habitually indulged in ample exercise. Such was Sir Walter Scott's distribution of his time, and such I know to be that of one of our ablest living writers.

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* Caldwell's Discourse on Physical Education, p. 87.

† See the chapter on the "Conditions to be observed before and after eating," in the Author's Physiology of Digestion.

There are, no doubt, individuals so happily constituted, and whose natural sphere is so essentially that of activity, that they are able to think and work early and late, for years in succession, with very little sleep, and with little regard to diet and regimen; but they are so obviously exceptions to the general rule, that we cannot for a moment hold them up as models for imitation. And even they would enjoy their astonishing gifts with greater security, were they to conform more completely to the laws of the organism.

Intervals of rest should also be carefully observed in conducting mental exercise and moral training, otherwise the results will be unsatisfactory. We are all familiar with the advantages of a period of repose after active muscular exertion, and must have noticed the renewed zest with which games are resumed in youth after an interval of rest. The same principle holds in regard to exercise of the brain and mind. After long-continued application the molecular condition of the brain is changed (p. 113), the attention flags, and further study, if persevered in, is comparatively unprofitable. After a sufficient interval of repose, however, the mind regains its elasticity, and returns with zest and alacrity to the subject which formerly wearied it. Hence, as observed by Simond, "the artist draws better after laying down his pencil for some time, or plays better on an instrument; fencing, swimming, are improved likewise. We have, however, neither studied nor practised" during the interval which has elapsed; "the mind, as far as we know, has been inactive, as well as the hand. Should we know *little* before the interruption, we are apt indeed to forget that little; but, if the skill was sufficiently perfect, it increases during a certain period of inaction, becomes stationary when longer intermitted, and is lost at last by protracted disuse."* These results are in perfect harmony with the principles of exercise explained in chapter vii., and the improvement observable after a proper interval of inaction is simply an indication that the exhausted organ has now recovered its tone, and acquired increased dexterity from its previous exercise. Something of the same kind has often been experienced in the confusion of mind which comes on at night after severe application to study. The jaded literary or scientific labourer goes to bed hopeless and dispirited, because the brain and mental energies are exhausted. After a sound sleep he awakes in the morning with renewed energy and a clear head, and finds he has really made greater progress than he imagined.

Periodicity, or the tendency to resume the same mode of action at stated times, is peculiarly the characteristic of the nervous system; and on this account *regularity* is of great consequence in exercising the moral and intellectual powers. All nervous diseases have a marked tendency to observe regular periods, and the natural inclination to sleep at the approach of night is but another instance of the same fact. It is this principle of our nature which promotes the formation of what are called habits. If we repeat any kind of mental effort every day at the same hour, we at last, when the time approaches, find ourselves entering upon it without premeditation; and, in like manner, if we arrange our studies in accordance with this law, and take up each regularly in the same order, a natural aptitude is soon produced, which renders application more easy than when the subjects are taken up as accident may direct. Nay, occasionally, the tendency to periodical and associated activity becomes in the course of time so great, that the faculties seem to go through their operations almost without conscious effort, while their facility of action becomes so prodigiously increased as to give unerring certainty where at first great difficulty was experienced.*

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* Simond's Travels in Great Britain, vol. i., p. 14.

In thus forming habits and acquiring readiness, we merely turn to account that organic law which associates increased aptitude, animation, and vigour, with regular exercise. It is not the soul, or abstract principle of mind, which is thus changed, but simply the organic medium through which it acts; and when we compare the rapid and easy eloquence of the practised orator with the slow and embarrassed utterance which distinguished him at the outset of his career, we have merely a counterpart, in the organ of mind, of what is effected in the organs of motion, when the easy and graceful movements of the practised dancer, writer, or pianoforte player, take the place of his earliest and rudest attempts.

The reader will now be prepared to understand the difference between *the manner* in which, and *the subjects* on which, the various faculties of the mind ought to be exercised. In ordinary education, the former has been, in a great measure, left to the determination of chance or caprice, although it is, in reality, of even greater importance, as concerns the results, than the right selection of the subjects to be taught. The exposition which I have given of the physiological conditions under which the different mental powers act, will, it is hoped, tend to prevent the continuance of this error, and lend some aid towards a choice of subjects more in accordance with the moral and intellectual nature of man. Hitherto, reading, writing, and arithmetic, have been almost the only branches taught to the working classes; and even the more comprehensive scheme of Mechanics' Institutions embraces the education of the perceptive faculties only, and makes no direct provision for the training of the higher intellectual and moral powers, which, nevertheless, are intended to be the guides of our conduct, and the main sources of our happiness.

It would require a separate volume to discuss satisfactorily the whole subject of education, and to decide upon the relative importance of different branches of knowledge for different ages, sexes, professions, and classes of society. I must therefore wholly abstain, at present, from the consideration of the latter branch of the inquiry, and content myself with remarking, that in every case, without exception, whatever the kind of education to be given, it is of the utmost practical consequence, that in *the manner of communicating it* we should act in accordance with the physiological laws which preside over the operations of the mind. Whatever we attempt to teach, whether merely reading and writing, or the higher truths of intellectual and moral science, our success will depend, in a great measure, on the extent to which we act in accordance with the laws of physiology *in our mode of teaching;* and for this simple reason I cannot regard any teacher or parent as fully and conscientiously qualified for his duties, unless he has made himself acquainted with the nature and general laws of the animal economy, and with the direct relation in which these stand to the principles of education.

The brain, as the instrument of the mind, is, like the muscles, liable to be strengthened by judicious exercise, or enfeebled by overwork. Every body admits that one man is capable of undergoing much more muscular exercise than another; but the truth that one brain is capable of undergoing much more intellectual labour than another is not so generally recognised. And even where it is theoretically admitted, it is too often practically neglected; for the simple reason that more reflection is required to perceive the abuse of the cerebral organs. The nervous system is the noblest and most characteristic part of man, through which he acquires his proud pre-eminence as an intelligent being. Yet how often do we find the culture of the brain entrusted to teachers destitute of every qualification for the task, and who have resorted to tuition as a last resource against want! No one thinks of being a dancing-master or a fencing-master without having in the first place educated his own muscular system in the exercises of fencing or dancing; but multitudes are ready to undertake the cerebral cultivation of the young, though entirely ignorant of the true principles of education. How many young women have to mourn over health permanently injured, from having been confided to the care of boarding-school mistresses, whose qualifications for the proper discharge of their duties were limited to a superficial knowledge of French and Italian, with drawing and music! How many sufferers from crooked spines, weakened stomachs, and shattered nervous systems, may be found in England as examples of the evils which result from confiding to ignorant hands the education of the young!

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* These remarks are curiously confirmed by an anecdote of Silvio Pellico, which I read in the Foreign Quarterly Review (No. xxii., p. 478), when this sheet was first passing through the press. When first imprisoned, Pellico was "allowed the use of a copy of Dante and the Bible. Of the former, he used to commit a canto to memory every day, till at last the exercise *became so mechanical that it ceased to afford any interruption to the train of melancholy thought.*" I need scarcely point out the coincidence between this and the remarks in the text.

It may be remarked, that in the preceding pages I have made but scanty allusion to the doctrines of phrenology. My reasons are simply, that, for the object I had in view, a special reference to them was not necessary, and that, in a work written for the general reader and for practical purposes, I was naturally anxious to avoid every contested point. Accordingly, in limiting myself to the statement that different parts of the brain perform different functions, without minutely specifying those connected with any particular part, I am not venturing beyond what most eminent anatomists and physiologists, in the past or present times, have taught before me.* My own opinions on the subject have been long before the public, and I am bound to say that every day's experience increases my conviction of the truth of phrenology, and deepens my sense of its practical value. Every real improvement made in education serves to bring the public a step nearer a just appreciation of the truth of phrenology and its extreme importance to the parent and educator, as well as to the physician and philosopher. Phrenology being true, every real improvement in intellectual teaching and in moral training must rest on a phrenological basis, whether that basis be recognised or not. Hence, some of the most remarkable advances lately made by practical and reflecting educators as the results of their experience, prove to be merely excellent illustrations of principles long since established by the phrenologists. I therefore speak advisedly when I repeat, that every step made in advance by purely practical men, will serve to render the truth and merits of phrenology more plain and acceptable to the public mind. Already hostile prejudices are rapidly disappearing, and ere many years they will have become a matter of history, and phrenology take that place which, as the true philosophy of mind and of man, it is entitled to occupy. The dislike with which it is still regarded by many intelligent persons who remain unacquainted with its doctrines, arises in a great measure from its being supposed by them to be opposed to *all* their previously acquired facts and opinions. This, however, is a great and pernicious mistake; for whatever is true in human nature is also true in phrenology; and consequently the facts gathered from life by the shrewd observer of mankind are either identical, or in absolute harmony, with the facts of phrenology. The chief difference is, that while common observation leaves its results so unconnected and confused as to have but little practical value, phrenology affords principles of arrangement by which its facts naturally assume a systematic form, and become highly available for use.*

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* The early education of the particular mental faculties which phrenology expounds, is, however, treated of in my work on the Management of Infancy, chapters xv. and xvi.

CHAPTER XV.

INFLUENCE OF THE NERVOUS SYSTEM UPON THE GENERAL HEALTH.

Having now examined the relations subsisting between the nervous system and the functions of animal life, and shewn how far the health of the brain depends upon the well regulated exercise of the mental faculties, I shall next advert to the influence of the nervous system upon the general health. But before doing so it will be proper, for the sake of greater clearness, to introduce a few remarks on the nature and uses of the *ganglionic* system of nerves, as distinguished from those of the *cerebro-spinal* system.

The ganglionic nerves, unlike those of animal life, have no direct connection with the brain, medulla oblongata, or spinal marrow, but arise from a number of distinct nervous masses or *ganglions* of a round, oval, or irregular form, situated in the neck, chest, and abdomen, in front of the vertebral column, and connected with each other by small nervous filaments. They constitute distinct nervous centres which preside over the organic functions, and their principal branches are accordingly distributed to the heart and blood-vessels, the lungs, the digestive and abdominal organs, the glands, and other parts concerned in nutrition and the support of life. Other branches serve to connect them with the cerebro-spinal system, and to a certain extent to bring them under its influence.

Even the mere explanation of the names by which the two portions of the nervous system are designated, marks out sufficiently for our present purpose the principal points of difference betwixt them. Thus the one set of nerves is called the *cerebro-spinal*, from its origin in the brain and spinal marrow; the other is called *ganglionic*, from taking its rise from ganglions. The one is called the *animal* system, from its connection with functions peculiar to animals; the other is called *organic* or *vegetative*, from its presiding over the function of nutrition, which is common to both animals and vegetables. The one is called the *voluntary* system, from its general subservience to the commands of the will; the other is spoken of as the *involuntary* system, because its action cannot be modified by the will, and it goes on whether we will or not. In addition to all these designations, the latter is also frequently termed the *sympathetic* system of nerves, from its being supposed to be the medium through which all the important organs of the body affect, or sympathize with, each other. Objections, however, may be made to the use of any of these terms, as drawing definite lines of demarcation, which, according to many physiologists, do not in reality exist.

But although the will has no direct power over the nerves of organic life, experience shews that the state of the mind exercises no small indirect influence over them and the organs on which they are ramified. The numerous connections between the *cerebro-spinal* and *ganglionic* systems point to this inference; and we have demonstrative proof of the fact in the sudden quickening of the action of the heart on a joyful surprise; in the excessive palpitations excited by alarm and anxiety; and in the sickness of stomach, loathing, and faintness, so often seen to follow violent mental emotion.

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* See a pamphlet by the Author, entitled "Phrenology—its Nature and Uses: An Address to the Students of Anderson's University, Glasgow," reprinted from the Phrenological Journal, vol. xix., p. 97: Also his "Life and Correspondence," *passim*.—Ed.

The action of the ganglionic nerves, then, is *entirely* involuntary, and in this respect differs from that of the cerebral and spinal nerves. By means of the latter we can at pleasure excite, direct, or arrest the motions of the ordinary muscles. But we have no such control over the muscles placed under the influence of the ganglionic nerves. The heart, for instance, continues to beat whether we wish it or not, and its action goes on during sleep, when our consciousness is buried in oblivion, with the same regularity as when we are wide awake. In some of the lower animals it continues to beat for hours after it has been removed from the body; and there are even instances recorded in which the excised heart of a fish continued to beat till it actually rustled from desiccation. This continued action after removal from the body, is most readily explained by supposing that the ganglions which lie in the walls of the heart yield sufficient nervous energy to produce contraction. In like manner, when digestion is going on, the muscular coat of the stomach and intestines contracts, not only without the will being able to prevent or accelerate it, but without our being in the least conscious of either its contraction or relaxation; and on opening the body of a decapitated animal, the peristaltic movements may be observed to continue for a considerable time, thus clearly proving that they do not depend on cerebral influence. But many physiologists are of opinion that the spinal cord is concerned in them: for instance, experiments on frogs have shewn that these animals continue to digest and excrete after removal of the brain and spinal cord;* but in this case the excretions accumulate in the bladder and intestinal canal, thus indicating that the contractile power of the bladder and intestines is at all events indirectly connected with the cord. This is farther proved by the obstinate constipation of the bowels which accompanies paralysis arising from disease of the spinal cord. An additional proof of the intimate connection which subsists between the intestinal tract and the spinal cord is seen in the fact that when the mucous membrane of the bowels is irritated, the stimulus is frequently transmitted to the cord, and is then reflected on the motor nerves, producing convulsions. Thus, in children, where the tendency to reflex motions is stronger than in adults, convulsions are frequently produced by the presence of worms in the intestines. This question has been experimentally elucidated by Valentin.*

In the healthy state, the ganglionic nerves also differ from those of the cerebro-spinal system in being devoid of sensation; and hence we have no consciousness of the action of any of the organs to which they are distributed. We are not only not aware of what is going on in the heart, the liver, the stomach, or the lungs, but we have no perception even of their existence, and the heart itself has been wounded without any consciousness of the fact on the part of the individual.

A few moments' reflection will suffice to shew the blessings which this want of consciousness confers upon us. Had we been able to trace the passage of our food along the alimentary canal, or that of our blood along the arteries and veins; or had the movements of the heart and lungs been evident to us, our attention would have been closely occupied in watching these phenomena, and our fears roused lest any derangement should ensue. Had the mucous membranes, too, been endowed with sensitive nerves, the gift would, under certain circumstances, have proved most distressing. An itching sensation of the alimentary canal without the possibility of rubbing or scratching would have been insupportable.

In disease, however, when the ganglionic nerves become morbidly irritable, sensations of a disagreeable kind are apt to arise, and sometimes of such a nature as to convey to the mind a dim consciousness of the existence of the affected organ. I have myself experienced something of this kind for several weeks in an unpleasant consciousness of the different action of the two sides of the heart.

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* Valentin's Lehrbuch, vol. ii., part 2d, p. 533.

* Valentin's Lehrbuch, vol. ii., part 2d, p. 485.

In more severe disease these disagreeable sensations frequently, but not always, become acute pain, from the derangement of the organs being made known to the brain, through means of those nervous branches which form the communication between the ganglionic and the cerebro-spinal systems. Hence pain becomes the monitor of morbid action, advising us that the condition of health has ceased, and warning us to take steps to remedy the evil. Pain, then, is but a symptom of disease, but in certain irritable constitutions it is liable to become so intense as to prove the chief source of danger, from the depressing effect it exercises upon the vital powers. Hence the positive necessity for having recourse in such cases to narcotic drugs to deaden sensibility, and hence also the utility of allowing the inhalation of the vapour of chloroform in surgical operations, and even in confinements. The action of chloroform is first apparent in the brain, which it renders incapable of perceiving the sensations produced in the automatic system, even where consciousness is retained. When its action is pushed further, and the functions of the brain are altogether suspended, consciousness is destroyed. The spinal cord and ganglions, however, continue to act, and respiration, the circulation of the blood, and the action of the womb, are not interfered with; because the lungs, the heart, and the womb, act independently of the brain. But an over-dose of chloroform, or of any narcotic drug, by extending its action to the spinal cord and ganglions, paralyses *them* likewise, and renders them incapable of affording the requisite supply of nervous energy. In such cases death ensues from the failure of the nervous power.

Extensive disease frequently takes place without pain giving any evidence of its existence. This happens most commonly when the disease is situated in the large glands, such as the liver or kidneys: and hence, the absence of pain is by no means indicative of the absence of serious injury. But the discussion of this topic does not come within the sphere of the present work.

As, then, the fact is undeniable, that both the animal and the organic portions of the nervous system exercise a powerful influence on the action of all our bodily organs, it becomes a matter of some importance to ascertain in what manner that influence operates, and under what conditions it may be rendered beneficial to health, and consequently to the increase of our happiness. The subject has not yet been examined with all the care which its importance requires, but a general survey of it will give the reader some idea of its real interest.

The nervous energy is considered by many to be identical with electricity; and this opinion at first sight seems countenanced to some extent by the fact, that muscular contraction and other results arising from nervous action can be produced also by means of electricity. But in reality the subject is still involved in great obscurity, and physiological researches must be greatly extended before we shall be able to determine positively in what manner the nervous system produces its effects on the living functions, or what is the exact nature of the influence which it exerts. There can be no doubt that electricity may be developed in the animal body, for this is proved indisputably in the case of the electric fishes; and it is also clear that this power is in close connection with the nervous system. Hunter shewed that the most characteristic feature of the organisation of the electric battery in the torpedo is its enormous supply of nervous matter, each electric nerve being generally as thick as the spinal cord; and Mr Faraday has demonstrated by experiments on the gymnotus, long preserved at the Adelaide Gallery in London, and now in the

Polytechnic Gallery, the identity of the imponderable secretion of the battery of the fish with electricity. "Needles," says Professor Owen, who was present at the experiments, "were converted into magnets; iodine was obtained by polar decomposition of iodide of potassium; and, availing himself of this test, Professor Faraday shewed that any given part of the organ is negative to other parts before it, and positive to such as are hehind it. Finally, heat was evolved, and the electric spark obtained." A stimulus to the battery is necessary for the discharge of electricity, precisely as a stimulus to the muscles is necessary to produce contraction. "The electric, like the motory nerves," says Professor Owen, "rise from the anterior myelonal[*] tracts. An impression on any part of the body of the torpedo is carried by the sensory nerves either directly, or through the posterior myelonal tracts, to the brain, excites there the act of volition, which is conveyed along the electric nerves to the organs, and produces the shock: in muscular contraction, the impression and volition take the same course to the muscular fibres. If the electric nerves are divided at their origin from the brain the course of the stimulus is interrupted, and no irritant to the body has any effect on the electric organs any more than it would have under the like circumstances on the muscles. But if the ends of the nerves in connection with the organ be irritated, the discharge of electricity takes place, just as irritating the end of a motor nerve in connection with muscles would induce its contraction. If part of the electric nerves be left in connection with the brain, the stimulus of volition cannot, through these, excite the discharge of the whole organ, but only of that part of the organ to which the undivided nerves are distributed. So, likewise, the irritation of the end of a divided nerve in connection with the electric apparatus, excites the discharge of only that part to which such nerve is distributed."[*] There exists, then, a close analogy between the electric action and muscular contraction, and this analogy is further seen in the increase of both by augmented respiration and circulation, in their exhaustion by exercise, and recovery by repose. This close relationship is also shewn by the direct action of strychnia on the nervous centres; its application causing simultaneous convulsive contractions of the muscles, and a rapid succession of involuntary electric discharges. These facts, however, are far from proving the *identity* of the nervous force with electricity, or even the mutual convertibility of these two agents. The nervous stimulus which enters the electrical organ acts simply as an exciter of chemico-vital changes, the result of which is a development of electricity. When the nervous stimulus enters a muscle, analogous chemical metamorphoses are produced; but the result of these changes, as determined by the organ in which they take place, is here muscular contraction. Hence, whatever excites chemical changes of matter in any organ calls the special function of that organ into play: mechanical irritation of a muscular nerve causes the muscle to contract, and irritation of an electrical nerve gives rise to a shock of electricity; but in neither case is the mechanical irritation identical with, or convertible into, muscular contraction or electrical power—it merely excites changes, the result of which is the production of these phenomena. A careful consideration of the details above mentioned will shew that there is nothing more wonderful in a sudden shock of electricity proceeding from an animal, than a sudden muscular contraction. Both powers are latent till the requisite nervous stimulus is applied, when a development of force takes place in each, according to precisely analogous laws, the degree of force depending on the amount of the stimulus and the condition of the generating organ. It would not, however, be in accordance with the intention of the present work to pursue this subject farther; and I shall, therefore, instead of attempting to use language apparently exact and scientific, but in reality still indeterminate and apt to mislead, adopt the popular form of expression, and speak of the nervous energy as if it were known to be, what many suppose, a fluid or influence of a peculiar nature, conveyed from the brain towards all parts of the body by means of the nerves, as blood is from the heart by means of the blood-vessels. For all practical purposes, this language will be more generally intelligible than any other; and all risk of error may be avoided if the reader will bear in mind, that, in using it, I do not profess to explain either what the nervous energy really is, what conditions are indispensable for its production, or in what precise way it produces the results which are observed to follow its action. All that is essential for our purpose is to be aware, *first*, that an active influence of some kind is brought into operation by the nervous system, and, *secondly*, that the effects produced by it upon the different organs and functions of the body vary according to the mode in which, and extent to which, that influence is exerted. Both of these points may be examined and turned to practical account, whatever theory be adopted to explain them.

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[*] From μυελος, *myelos*, the spinal cord.

[*] Owen's Lectures on the Comp. Anat. of the Vertebrate Animals, p. 216.

All, then, that need be said here of the nature of the nervous energy is, that it is an influence of a peculiar kind, originating in and conveyed by nervous matter, and that, like the blood, it is essential to the vital action of every animal organ. When I move the hand in writing, the muscles of the arm are called into play by an influence transmitted to them from the brain by means of the nerves. This stimulus is so indispensable, that, if the communication between the brain and the muscles be cut off by dividing or tying the nerve, no effort of the mind will longer suffice to excite them to action. In like manner, if the nerves of the stomach be cut through, so as to interrupt the flow of nervous influence, digestion will cease, or, at all events, be greatly interfered with, although in every other respect the stomach remain uninjured.

Changes in the quality or amount of the nervous influence transmitted from the brain to any organ have thus a direct power of modifying its function. If, for example, from the peculiar state of the brain accompanying mental distress, the nervous influence sent to the stomach be impaired, the tone of that organ will also be impaired, and digestion become imperfect; whereas if, in consequence of pleasing excitement, the nervous stimulus be increased or improved, a corresponding activity will be communicated to the stomach, and digestion will be facilitated, as is experienced after a dinner in pleasant society.

Something analogous to this is still more visibly exhibited in the case of the muscles. If the mind be active and decided, the muscles, receiving a strong stimulus, move with readiness and force; but if the cerebral activity be impaired by bilious depression, muscular action becomes slow, infirm, and indolent. Accordingly, muscular debility is one of the first symptoms of many of the diseases of the brain and spinal cord. The patient complains of want of tone in the muscles, of being easily tired, and of being obliged to rest frequently. More decided symptoms of weakened muscular power soon follow; there is hesitation of speech, the tongue acquires a tremulous motion, and other symptoms of paralysis gradually develope themselves in consequence of the lessening flow of a healthy stimulus from the nervous system. But if, on the other hand, the brain be excited by strong passion, and the stimulus be thus augmented, the muscular movements become energetic and decided, and are sometimes performed with a force that is truly surprising.

As the kind of nervous influence depends on the condition of the brain, that which springs from a brain of which all the parts are in sound and vigorous action is the most salubrious.

Mental indolence and high mental excitement are alike inimical to bodily health; and consequently our great aim should be to secure for every mental power, moral as well as intellectual, that equal and regular exercise from which alone the proper nervous stimulus can spring.

It is indeed interesting to observe the effects of the nervous influence, as varied according to the faculties in predominant action at the time it is produced. If the higher feelings have the ascendency, and the more selfish propensities be merely active enough to give force to the character, without setting the mind at war with itself, the nervous influence is the most grateful and efficient which can be imagined for sustaining the healthy co-operation of the whole body. This result follows, because the Creator evidently designed such a state of mind to be the best and happiest for man himself, and has therefore taken care to surround him with every motive to induce him to enter into it.

If, however, the lower feelings be in great activity, and impel to designs and conduct repulsive to the moral sentiments, so that the faculties are ranked in opposition to each other—or if the mind be oppressed with grief, anxiety, or remorse—the stimulus which the brain gives will be far from beneficial, because no longer in accordance with the conditions designed by the Creator. It is in such circumstances, accordingly, that bad health is so often seen to arise from the state of the mind, and that suffering is produced which no art can relieve till the primary cause has ceased to exist.

Similar results follow over-exercise of the intellect and inactivity of the feelings. From the concentration of vital action in the brain, the stomach and other organs are unprovided with the requisite nervous stimulus, and become impaired in their functions; and hence the dyspeptic and hypochondriacal symptoms which so often render life a burden to literary men. Persons so situated, when advised to attend to diet, often answer that it is in vain, and that, while at some times nothing can be digested, at other times, perhaps within a few hours or days, nothing comes amiss—the power of digestion varying thus quickly according to their mental condition. Whereas, when indigestion arises from a primary affection of the stomach, the least deviation in the way of indulgence proves injurious. In both instances, attention to diet is beneficial; but in the one it is less rigidly important than in the other.*

The influence of the brain on the digestive organs is so direct, that sickness and vomiting are among the earliest symptoms of many affections of the head, and of wounds and injuries of the brain; while violent emotions, intense grief, or sudden bad news, sometimes arrest at once the process of digestion, and produce squeamishness or loathing of food, although, an instant before, the appetite was keen. Narcotics, the direct action of which is on the brain, have a similar effect on the stomach.

The influence of the mind and brain over the action of the heart and lungs is familiar to every one. The sighing, palpitation, and fainting, so often witnessed as consequences of emotions of the mind, are evidences which nobody can resist. Death itself is not a rare result of such excitement in delicately organized persons.† During sleep, when the action of the brain is suspended, the animal heat shews a tendency to decline, and the body becomes more liable to be influenced by the causes of disease. Chossat's experiments have shewn that this depends on the chemical metamorphoses which produce the animal heat being lessened during sleep, owing to the withdrawal of the cerebral stimulus. We have already seen that, in accordance with these observations, the attacks of epidemics occur most frequently during the night.*

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* See my Treatise on Digestion and Diet, chap. xi.

† "It not only appears that a simple withdrawal or disturbance of the nervous force supplied to particular organs occasions a retardation or perversion of their vital operations; but there also seems evidence that an influence of an opposite kind may be transmitted through the nervous system, which is positively and directly antagonistic to the vital powers of the several tissues and organs;—such, at least, appears to be the only mode of accounting for the extraordinary effect of a shock, mechanical or mental, in at once and completely destroying the contractility of the heart, &c."—Dr Carpenter in Phil. Trans., 1850, p. 740.

By the laws which govern our constitution, therefore, the regulated activity of both intellect and feeling is made essential to sound bodily health; and this seems to me one of the most beautiful arrangements of an all-wise and beneficent Creator.

If we shun the society of our fellow-creatures, and shrink from taking a share in the active duties of life, mental indolence and physical debility beset our path. But if, by engaging in practical business, and doing what we can for the advancement of society, we duly exercise our various powers of perception, thought, and feeling, we promote the health of the whole corporeal system, invigorate the mind itself, and at the same time experience the highest mental gratification of which a human being is susceptible,—that of having fulfilled the object of our existence, in the active discharge of our duties to God, to our fellow-men, and to ourselves. If we neglect the exercise of our faculties, or withdraw them from their objects, we weaken the organism, give rise to distressing diseases, and at the same time experience the bitterest feelings that can afflict human nature—ennui and melancholy. The harmony thus shewn to exist between the moral and physical worlds, is but another example of the numerous inducements to that right conduct and activity, in pursuing which the Creator has evidently destined us to find terrestrial happiness.

The reader will now understand why the state of the mind is so influential in the production and progress of disease. In the army this principle has often been exemplified in a very striking manner, and on so large a scale as to put its influence beyond a doubt. Sir George Ballingall mentions in his Lectures on Military Surgery, that the proportion of sick in garrison in a healthy country, and under favourable circumstances, is about five per cent.; but that, during a campaign, the usual average is nearer ten per cent. So marked, however, are the preservative effects of cheerfulness and the excitement of success, that, according to Vaidy, the French army cantoned in Bavaria after the battle of Austerlitz had only 100 sick in a division of 8000 men, being little more than *one* in the hundred. In like manner, an extraordinary degree of health prevailed in the British fleet in the West Indies in April 1782, evidently in consequence of the brilliant and decisive victory achieved by Lord Rodney over the French fleet on the 12th of that month. Sir Gilbert Blane, who was present on the occasion, ascribes the fact chiefly to this cause, and remarks "of what importance it is in point of health to support the spirits of men; depression of mind not only damping their courage, but being favourable to the invasion of disease in every form. There is," he adds, "perhaps no disease which low spirits are so apt to produce as the sea-scurvy: it is important, therefore, to encourage such innocent and salutary recreations as music and dancing."* Dr Rush adduces another striking illustration from the history of the American War of Independence. "The Philadelphia militia," says he, "who joined the remains of General Washington's army in December 1776, and shared with them a few days afterwards in the capture of a large body of Hessians at

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* See page 171.

* Select Dissertations on Several Subjects of Medical Science, by Sir Gilbert Blane, Bart., Physician to the King, p. 79. London, 1822.—He refers in a note to "a like example of the happy effect of an exalted state of mind in sustaining hardship and fatigue, in the army of India while crossing the desert in their route to Egypt in the year 1801," recorded by Sir James Macgrigor in his Medical Sketches.

Trenton, consisted of 1500 men, most of whom had been accustomed to the habits of a city life. These men slept in tents and barns, and sometimes in the open air, during the usual colds of December and January; and yet there were only two instances of sickness, and only one of death, in that body of men in the course of near six weeks, in those winter months. This extraordinary healthiness of so great a number of men under such trying circumstances, can only be ascribed to the vigour infused into the human body by the victory of Trenton having produced insensibility to all the usual remote causes of diseases."*

When, on the other hand, an army is subjected to privations, or "*is discouraged by defeat or want of confidence in its chiefs,*" the proportion of sick is "*often fearfully increased.*"† For instance, in the disastrous Walcheren expedition of 1809, this concurred with other causes in producing a frightful amount of disease and mortality.

The same principle explains why it is so important for the physician to carry the feelings of the patient along with him in his curative measures. It is well known, for example, that those who live in constant apprehension of fever, cholera, or any other ailment, are generally among its first victims when exposed to its causes. The reason is obvious. The depressing nervous influence resulting from the painful activity of the selfish feelings, affects all the organs of the body, and places them on the brink of disease, even before any external cause is in operation; and hence the easy inroad which the latter makes when it comes into play.

The influence of the state of the mind on health is well exemplified in recruits for the army. According to Dr Henry Marshall, regret for having enlisted, and separation from friends, make them brood over the inconveniences attending their new mode of life, and their health suffers in consequence. These causes, combined with the fatigue of drill and the restraints of discipline, have so much influence, that "growing lads" frequently fall victims to them. The recruit, if not very robust, "loses that active fortitude which is required to fit him to bear up against difficulties, and falls into a gloomy state of mind, that is soon followed by deteriorated bodily health; he loses his appetite, becomes emaciated, a slight cough supervenes, and, after frequent admission into hospital, he at last dies of diseased lungs. This is an outline of the history of many a young lad who enlists in the army."* In France, where the conscription is compulsory, and many are of course serving against their will, the agency of depression of mind is still more marked and fatal. In the seven years extending from 1820 to 1826, both inclusive, it appears from the returns that the French army lost ninety-seven men from pure nostalgia, or home-sickness, an affection which is rarely fatal in this country.

So efficacious, on the other hand, is a more cheerful state of mind, from the more healthful nervous influence which it diffuses through the frame, that surprising recoveries occasionally happen, which can be ascribed to no other cause than this. A singular and instructive instance fell under the observation of Sir Humphry Davy, when, early in life, he was assisting Dr Beddoes in experiments on the inhalation of nitrous oxide. Dr Beddoes having inferred that the oxide must be a specific for palsy, a patient was selected for trial, and placed under the care of Davy. Previously to administering the gas, Davy inserted a small thermometer under the tongue of the patient to ascertain the temperature. The paralytic man, wholly ignorant of the process to which he was to submit, but deeply impressed by Dr Beddoes with the certainty of its success, no sooner felt the thermometer between his teeth than he concluded the talisman was in operation, and, in a burst of enthusiasm declared that he already experienced the effects of its benign influence throughout his whole body. The opportunity was too tempting to be lost. Davy did nothing more, but desired his patient to return on the following day. The same ceremony was repeated; the same result followed; and *at the end of a fortnight he was dismissed cured,*—no remedy of any kind except the thermometer having ever been used.* Quacks profit largely by taking advantage of this principle of our nature: and regular practitioners would do well to bestow more pains than they do in assisting their treatment by well-directed moral influence. Baglivi was deeply impressed with this opinion when he said, "I can scarcely express how much the conversation of the physician influences even the life of his patient, and modifies his complaints; for a physician powerful in speech, and skilled in addressing the feelings of a patient, adds so much to the power of his remedies, and excites so much confidence in his treatment, as frequently to overcome dangerous diseases with very feeble remedies, which more learned doctors, languid and indifferent in speech, could not have cured with the best remedies that man could produce." Dr Rush also insists strongly on the utility of inspiring hope, and states that he frequently prescribed remedies of doubtful efficacy in the critical stage of acute diseases, "but never till I had worked up my patients into a confidence, bordering upon certainty, of their probable good effects. The success of this measure has much oftener answered than disappointed my expectations."†

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* Medical Inquiries and Observations, by Benjamin Rush, M.D., vol. i., p. 219, ed. 1789.—In the same volume Dr Rush gives "The Result of Observations made upon the Diseases which occurred in the Military Hospitals of the United States during the late War," and states, among other facts, that "those officers who wore flannel shirts or waistcoats next to their skins, in general escaped fevers and diseases of all kinds."

† Medico-Chirurgical Review, No. xxxvi., p. 430.

* Marshall on the Enlisting and Discharging of Soldiers, p. 5.

Another remarkable instance occurred during the siege of Breda in 1625. When the garrison was on the point of surrendering from the ravages of scurvy, a few vials of sham medicine introduced by the Prince of Orange's orders, as the most valuable and infallible specific, and given in drops as such, produced astonishing effects: "*Such as had not moved their limbs for months before, were seen walking in the streets, sound, straight, and whole;* and many who declared they had been rendered worse by all former remedies, recovered in a few days, to their inexpressible joy."*

Every one, indeed, who has either attended invalids, or been an invalid himself, must often have remarked, that the visit of a kind and intelligent friend is highly useful in dispelling uneasy sensations, and in promoting recovery by increased cheerfulness and hope. The true reason of this is simply that such intercourse interests the feelings, and affords an agreeable stimulus to several of the largest organs of the brain, conducing thus to the diffusion of a healthier and more abundant nervous energy over the whole system. The extent of good which a man of kindly feelings, sound sense, information, and a ready command of language, may do in this way, is much beyond what is generally believed; and if this holds in debility arising from general causes, in which the nervous system is affected not exclusively but only as a part of the body, it must hold infinitely more in nervous debility and in nervous disease; for then the moral management is truly the medical remedy, and differs from the latter only in this, that its administration depends on the physician, and not on the apothecary,—on the friend, and not on the callous attendant.†

In his excellent little treatise on Physical Education, Dr Caldwell justly remarks that the influence of a regulated and well-balanced activity in the moral and intellectual faculties on the general health, compared with that of active and boisterous passions, is like the salutary effect of mild and wholesome nourishment contrasted with the fiery potency of alcohol. The former is eminently conducive to life, health, and enjoyment, while the latter is as eminently opposed to them all. Of this truth Dr Caldwell gives an interesting example from the history of his own country. Of the fifty-six delegates who signed the Declaration of Independence, almost all were men of well-regulated and active minds, not marked by any excess of passion. Two of them died early from accidents. The aggregate years of the remaining fifty-four were 3609, giving to each an average of sixty-six years and nine months; thus affording a striking evidence of the salutary influence of the mind on health. From the same absence of active passion in mathematicians, the average duration of life in twenty of them, taken promiscuously by Dr Caldwell, extended to seventy-five years, while, in an equal number of *poets*, whose vocation greatly depends on excitability of feeling, the average was so low as fifty-seven.*

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* Paris's Life of Davy, p. 51.

† Observations on the Duties of a Phy-ian, op. cit. i. 250.

* F. V. Mye, De Morbis et Symptomatibus, &c., quoted by Dr Johnson in his treatise on Derangements of the Liver, &c., p. 206.

† On the subject of this paragraph, see the Author's Life and Correspondence, p. 410.—Ed.

The powerfully stimulating effect of healthy mental excitement on the bodily functions, is familiar to every one, and is duly noticed in the works of the novelist and poet. In nine cases out of ten, a visit to a watering place, or a journey through an interesting country, does more good by the beneficial excitement which it gives to the mind and brain, than by all the other circumstances put together. It is indeed greatly to the credit of the medical departments of both army and navy, that the influence of the mind in preserving and restoring health is more correctly appreciated and provided for than it is even in private practice. In the expeditions of Ross, Parry, and others, to the Northern Regions, the utmost attention was bestowed by the enlightened commanders to keep up a healthy vivacity of intellect and feeling among their men, by constant occupation, intellectual instruction, the representation of plays, masquerades, and other amusing and exciting exertions; and there cannot be a doubt, that the remarkable immunity of the sailors from disease was in no small degree owing to these admirable arrangements. From this may be seen the immense importance which attaches to the selection of a humane and considerate, as well as scientific commander.

In the second volume of Captain Basil Hall's first series of *Fragments of Voyages and Travels*, the reader will find a chapter on "*the effects of being well commanded*," which illustrates, very amusingly, many of the principles explained in the preceding pages. "People," says he, "who have no acquaintance with the intricacies of naval discipline, can scarcely comprehend how vast a difference is made in the efficiency of a man-of-war, by the character of the commander." "Early in the year 1805, we were made abundantly sensible of the truth of this remark, by an important change which took place in the highest office on board. From a state of languid inefficiency, we started in a single moment into the most vigorous activity, and from being almost the laughing-stock of the fleet, for the clumsiness of our gait, and the want of success which attended our cumbrous exertions, we soon outstripped them all, not only in activity, but in the useful result of our services."—(P. 2.)

The new captain was a man who knew his profession, and possessed that decision of character which makes its weight instinctively felt. Between certain disgrace and punishment to offenders, and "high favour to those who took pains to do right, the ship was speedily brought into proper trim. Every thing now seemed alive, and moved smartly; no time ran to waste; even the indolent and the ill-disposed found their best interest in working well. The decks became cleaner than they had ever been before; the people dressed themselves more tidily; the sails looked better furled; the yards better squared; *the complaints of inattention and drunkenness grew daily*

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* Caldwell on Physical Education, p. 84–6.

less frequent, and an air of general happiness, as well as new-born energy, spread itself over the whole ship."—"So magical indeed was the effect of this change, that I dare swear we should then have engaged and beaten an enemy whom it might not have been considered by any means prudent to have brought to action a week before."—(P. 17.)

Captain Hall gives other examples of the same principle, and remarks that, in this way, the simple fact of Nelson joining the fleet off Trafalgar, was almost equivalent to double manning every ship in the line. The explanation which he gives of the "mysterious agency" by which the genius of a commanding officer imparts a portion of its spirit to every one under his orders, is perfectly philosophical.

"When a person of talents is placed under an able commander, he feels confident that nothing he does will be passed without notice, and consequently that his exertions must tell to his advantage, exactly in proportion as their utility makes itself felt. This consciousness will, of course, stimulate him to fresh endeavours to excel; and, from thus feeling sure that his conduct is duly appreciated, he has an immediate motive to bring his whole strength into play,—an exercise which must ever produce good results."

But "suppose the case differently put, and let the superior in station be the inferior in abilities or experience, or not so zealous in the execution of his duty as the men he commands. The situation of the inferior is now far from being so independent, or so well calculated to draw forth his powers, as it was in the first case. The subordinate officer has no longer the same animated stimulus to exertion; for, his labours being generally unnoticed, or their results unappreciated, he is left without much encouragement to proceed in fresh endeavours to excel; *while his faculties, instead of improving, through generous exercise, are often deteriorated by the languid manner in which they are brought into play.*"—(P. 6.)

Captain Hall justly observes, that the influence of the commander on men of moderate talents is still more striking, as they stand more in need of a stimulus to duty. "If a commander has skill enough to enlist the sympathies of those placed under his orders, they will feel insensibly drawn on to make common cause with him, and will afterwards exert themselves strenuously to maintain that degree of importance derived from this implied companionship in ability, which they could hardly hope to reach single-handed."—"The invariable effect of these efforts is to improve the character. Such training will certainly not make a clever man out of a stupid one; but it may often render a discontented or useless man of service to himself and the state; and, instead of his continuing a wretched and hopeless being, may convert him into one who is happy and confident of success."

"I suspect, however, that no one who has not been an eye-witness of the condition of a ship under the command of an ignorant, trifling, or otherwise inefficient captain, can have any notion of the mischievous effects of his misrule, or rather of his no rule. Perhaps in the long-run, almost every kind of consistent severity is preferable to the uncertain higgledy-piggledy kind of discipline on board a man-of-war, in what is called slack-order. The moderately gifted persons feeling that, in these circumstances, they have no chance of notice by any exertions of their own, speedily degenerate into a sort of vegetables, so incapable of any useful exertion, that they infest the ship like the fungus called the dry-rot. This chaotic period is the holiday season of the scamps and sculkers, who then fancy their game the surest. These fellows certainly succeed in working as little as possible, and in making those about them unhappy; but, after all, without any great accession to their own comfort. . . .

"This system," continues Captain Hall, "discourages the cheerful and willing workers by the oppression of its injustice—a feeling which speedily takes away or deadens some of the best motives to improvement." Such a captain, unwilling to see that he himself is in fault, ascribes the evil to others; and, "by his unfair censure of those who, in fact, are the most deserving of commendation, he scatters *the seeds of discouragement over all the different classes exposed to his unskilful handling, and everything falls into confusion worse confounded*."—(P. 10.) The loss of the French frigate Medusa on the coast of Africa in 1817, and the tremendous suffering which instantly ensued from the state of anarchy and uproar which took place among the crew, are well known to have arisen entirely from the insufficiency and headstrong conceit of a weak and ignorant commander, and afford a strong contrast to the admirable coolness and high-toned moral feeling displayed on the similar occasion of the wreck of the Alceste, on her return from China with Lord Amherst, and which also made a deep impression, but of a widely different nature, on the public mind.

From the passages above quoted, the influence which the qualities of the commander may exert on the health as well as the discipline of those under his orders, may easily be inferred. So important, indeed, are cheerfulness and confidence, as conditions of health, that if two ships were to be sent out to circumnavigate the globe, each equal to the other in every respect, except the one being under the direction of a humane, vivacious, and considerate man, and the other of a lymphatic, selfish, and tyrannical commander, though both were equal in talent,—it is quite certain that the fate of the crews would be widely different, and that sickness would prevail much more in the one than in the other. In the expedition dispatched under the command of Sir James Ross in search of Sir John Franklin, the mortality among the crews considerably exceeded that of former expeditions; and this unfavourable feature was ascribed by their commander in a great measure to the depressing effect of failure.

CHAPTER XVI.

APPLICATION OF THE PRECEDING PRINCIPLES TO THE ORIGIN AND PREVENTION OF BAD HEALTH.

The reader is now prepared to take a correct view of a question on which it especially interests all to have true and precise notions. I allude to *the real origin of bad health.* On this point very vague and contradictory opinions are prevalent; and, as our conduct in life must necessarily be closely dependent on our views in regard to this subject, I cannot do better, before concluding, than devote a chapter to its consideration.

Setting aside, for the present, hereditary tendencies to disease (which, however, as they must have begun at first from ordinary causes with some progenitor, might properly enough have been considered in this place), bad health may be regarded in one of three different lights: *First*, as having no necessary connection with our conduct, but as being the result of circumstances entirely beyond our knowledge and control, and sent by a superintending Providence, not to urge us to more rational care, but to soften our hearts, and warn us from sin; *Secondly*, as the result of accident alone, or of external influences which we can appreciate, but from which it is impossible to withdraw ourselves; or, *Thirdly*, as, in every instance, the result of the direct infringement of one or more of the conditions decreed by the Creator to be essential to the well-being and activity of every bodily organ, and the knowledge and observance of which are, to a great extent, within our own power.

According as one or other of these views shall be adopted, the most opposite practical results will follow. If the *first* be received as the truth, and health and sickness be viewed as dispensed without reference to our treatment of our bodies, but solely as a means of reclaiming us from sin, attention to moral and religious improvement alone will be our best protection, and any attempt to avert bad health by studying and obeying the laws of the bodily functions will be entirely useless. If, again, the *second* principle be correct, and disease arise from accident and from influences beyond our control, then neither our moral nor our physiological conduct will avail us as a protection, and our only resource will be humble resignation to the will of God. But if the *third* be true, and the human frame be constructed by the Creator on principles calculated to carry on life for seventy years or longer, and if in fact a large proportion of the race perish before attaining ten years of age, chiefly from infringing the conditions on which the due performance of the various vital functions depends, it then becomes an object of great interest to us to study the structure of our organs, to discover the laws of their functions, and to yield to the rules thence deducible that implicit obedience from which alone health can spring.

That the strictest observance of the moral laws and the purest devotion of which human nature is capable, are, without a simultaneous observance of the organic laws, insufficient to secure health to the body, is too clearly proved by the instances already adduced, and by the history of mankind, to require any demonstration here. The biographies of the pious and excellent furnish abundant examples of the fact; while the annals of crime afford numerous instances of men of the most unprincipled characters enjoying unbroken health. If, indeed, the organic conditions be fulfilled, the upright man will enjoy a serenity of health which the criminal can never know; but the moral observance alone will not avail him, if he at the same time neglect the organic laws.*

In regard to the *second* proposition, a little reflection will satisfy every intelligent mind that it is equally untenable, and that disease is not always the result of accident or of circumstances which cannot be modified. There are causes of bad health against which even the most stupid and prejudiced take some precautions, and with success; and the whole art of medicine would be a more gross delusion than ever romancer imagined, if health were not influenced by circumstances within our control. All our remedies, and all our attention to diet, clothing, and regimen, are indications of the contrary persuasion. There are, indeed, agencies from which we shall probably never be able entirely to protect ourselves. Such are variations in the state of the atmosphere, epidemic and contagious causes, and necessary exposure, in pursuance of higher duties, to known unhealthy influences; but allowing for all these, *ample scope remains within which man may, by an extension of his knowledge and industry, provide himself with safeguards far beyond what he has ever yet made use of, or has ever dreamed of being able to discover.*

The *third* view, or that which ascribes bad health to the disregard of some one or more of the organic laws, thus presents itself as the only one in accordance with observation and past experience; and, after the full exposition I have already given of the conditions of health of various important organs, I trust that little farther proof of this will be required. At the same time, as the principle is full of practical value, I shall briefly mention some additional facts which go far to establish its accuracy.

Considering that the human frame is constructed to endure, in many cases, for sixty, seventy, or eighty years, it must seem extraordinary to a reflecting mind, that, taking the whole of the deaths in England and Wales for the seven years 1838–44, so large a proportion as 396 in 1000 should occur under the age of five years, and that in Manchester and Salford the proportion of deaths under the same age should rise to the enormous amount of 517 in 1000. It is impossible to suppose that such a rate of mortality was assigned by the Creator as the unavoidable fate of man; for, by the gradual improvement of society, and a closer observance of the organic laws, the proportion of deaths in early life is now much smaller than it was in former times. We have already seen that so recently as about the middle of last century, when the pauper infants of London were received and brought up in the workhouses, amidst impure air, crowding, and want of proper food, not above 1 in 24 lived to be a year old; so that out of 2800 annually received into them, 2690 died. But when the conditions of health came to be a little better understood, and an Act of Parliament was obtained obliging the parish officers to send the infants to nurse in the country, this frightful mortality was reduced to 450, instead of upwards of 2600 ! On comparing the various Reports of the Registrar-General we find that great differences exist in the mortality of different districts. It appears, for instance, that while the number of deaths among children under five years of age, amounts in Manchester and Salford to 517 per 1000 of the whole mortality, in Chichester it is only 275 per 1000. After making every allowance for a larger number of children existing in Manchester and Salford, in proportion to the rest of the population, than in Chichester, it remains evident that in the former two places there occurs annually a large sacrifice of human life which might be obviated by judicious sanitary measures. This becomes still more apparent when we compare the number of births in the two places with their respective infantile mortality. During the six years 1839–44 42,895 children were born in Manchester, and of this number 11,338, or 264 per 1000, died before completing the first year. In Chichester, again, the births during the same period amounted to 2507, and the deaths in the first year to 295, or 117 per 1000. Now, since it is morally certain that it formed no part of the great scheme of the universe that twice as large a proportion of infants should die in Manchester as in Chichester, the cause of the difference can only be, that in Chichester the conditions of health, prescribed in the nature of the human constitution, and of the things that surround and affect it, are better fulfilled than they are in Manchester. Can stronger evidence than that just cited be required to prove that bad health frequently arises from causes which man may often discover and remove, and which, therefore, it is his bounden duty to investigate and avoid by every means which Providence has placed within his reach ?

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* I may again refer to George Combe's work on "The Constitution of Man" for a consistent and intelligible view of the relation subsisting between the organic and the moral and intellectual laws.

The higher rates of mortality of adults as well as of infants in crowded cities than in country districts, as exhibited in the instructive returns of the Registrar-General, equally demonstrate the influence of bad air, crowding, and imperfect food, in abridging life. We are told, on the authority of M. Benoiston de Chateau-neuf, that about two-thirds of the children born in Paris are sent to the country to nurse, and that of these two-thirds, about three in five are reared; whereas, of the other third which remains in Paris, more than a half die during the first year. This difference of mortality is ascribed by M. Lachaise to the residence of a number of the mothers in dirty districts of the city, and to their occupying dark and ill-ventilated houses. From reasons of necessity too, it is principally the children of the poorer classes who are left in Paris, and these, from the poverty of the parents, are inadequately provided with clothing. Hence cold has no inconsiderable share in producing the result. From these combined causes the mortality is found to be much greater in the poorer than in the richer districts of the city.*

Even in the best managed communities, the number not only of the sick of all ages, but of those who are cut off in early youth, is so prodigious as to shew that we are far from having arrived at the maximum of health of which the race is susceptible; while the advances we have already made give us every reason to hope that, by perseverance and the extension of our knowledge, we may continue to improve for many centuries to come. The progress of knowledge, and the increasing ascendency of reason, have already delivered us from many scourges which were regarded by our forefathers as unavoidable dispensations of an inscrutable Providence.

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* Annales d'Hygiène Publique, April 1849, p. 341.

In the days of the ancient Romans, their capital and territories were frequently almost depopulated by visitations of plague and pestilence, from which the present generation is, by means of a stricter observance of the conditions of health, entirely exempted. In London, in like manner, the same contempt of cleanliness, ventilation, and comfort, which was so fatal to the Romans, produced similar results, and swept off its thousands and tens of thousands, till a fortunate disaster,—the great fire,—came in the place of knowledge, and, by destroying the crowded lanes and other sources of impurity which man had shewn himself so little solicitous to remove, procured for its inhabitants a perfect and permanent immunity from one of the deadliest forms of disease; thus teaching them the grand practical truth, that such awful visitations are not arbitrary inflictions of an offended Providence, but the direct consequences of the neglect of those conditions by which the various vital functions are regulated, and by conforming to which alone health can be preserved. Accordingly, by greater attention to proper food, cleanliness, and pure air, the mortality of London with its gigantic population, is now little above half what it was 200 years ago; and the huge city scarcely feels those ravages of cholera which have inflicted a blow on some less fortunate places, the effects of which will be long remembered. Formerly, the period of greatest mortality in London occurred in summer, owing to the influence of the solar heat in causing the rapid decomposition of the animal and vegetable refuse which encumbered the streets. The close and confined air acted as a concentrated poison, and plague and other fatal epidemics were the result. But *now* the winter season is the most unhealthy, owing to the injurious influence of the cold, from which the poor cannot adequately shelter themselves; while the summer air, from being less contaminated than formerly by deleterious exhalations, has become less destructive to life. It is apparently from the combination of dirt and heat that the cities of Southern Europe are in our own time more unhealthy during summer than those of the north.

The great influence of light, fresh air, and drainage, in improving the health of a city-population, has been recently illustrated on an extensive scale in the case of the city of Hamburgh. During the visitation of the cholera in 1832, there were, among the population residing in the dirty and close parts of the town, five times as many attacks, and nearly four times as many deaths, as among persons of the same class residing in the clean and airy part; that is, irrespective of the condition of poverty, the difference in the sanitary condition of those two parts of the town rendered the inhabitants of the one district five times more susceptible of the disease than those residing in the other, and increased the actual mortality of the most susceptible fourfold. But since the epidemic of 1832, a large portion of Hamburgh has been reduced to ashes by the great fire of 1842, and this part of the city has been reconstructed on a plan in conformity with sanitary principles. The result is thus stated by Mr Grainger, with reference to the cholera epidemic of 1848:—

"After extensive enquiries among several physicians, I am fully justified in stating that the rebuilt part of Hamburgh has experienced an exemption from cholera, which is as remarkable as it is important. All the medical men with whom I conversed upon the subject expressed themselves unequivocally to this effect; and, indeed, the thing is so notorious as to be well known to the inhabitants generally. Dr Rothenburg stated to me in evidence, that although there had not been time to classify the cases, it was clear that the epidemic had not advanced so far towards the Alster, or new part of the town, as in 1832. Other persons state that it has been particularly confined to persons living near the Elbe. Mr Völkers, whose office enabled him to form a more accurate judgment than other individuals, since it was his duty to take the address of all the applicants who came to the central bureau, in answer to my enquiries, states that from extended observation he had ascertained that, comparing the poor residing in the rebuilt parts of the town with those living in the old portion, not more than one of the former had been attacked with cholera for ten of the latter.

"As certainly as the per-centage of typhus decreases with improved drainage, paving, and ventilation, so also will epidemic cholera. The proof of this has been afforded on a grand scale at Hamburgh. The ravages of the disease have received a marked check in the present outbreak by the substitution of wide, open, and well-drained streets, for narrow, filthy, and damp thoroughfares; by the removal of high mounds of earth, blocking up the streets and overshadowing the houses; and by guarding a large evaporating surface from contaminations."*

Of late years associations have been formed in many of the large towns, both of England and Scotland, for providing cheap and comfortable accommodation for the poorer classes. Model lodging-houses and dwellings have been erected in the worst districts of the towns, and have already effected much good; directly, by affording greatly improved and healthy houses at a reasonable rate to the working population, and indirectly, by giving a stimulus to the keepers of the old lodging-houses and to house-proprietors to follow in the path of improvement. But the evil with which these associations have to grapple is almost too great for private enterprise to contend with, and many years must elapse before any very perceptible improvement can ensue, unless the municipal corporations move in the cause. Power for this purpose was granted by Parliament to the English municipal bodies in the session of 1850-51, and there is good reason to hope that it will speedily be acted on. As yet, all that has been accomplished is but as a drop in the bucket, and "nothing effectual," says the Registrar-General, in speaking of sanitary measures,* "has been done to put a stop to the disease, suffering, and death, in which so many thousands perish. The improvements, chiefly of a showy, superficial, outside character, have not reached the houses and habits of the people. The houses and children of a labouring man can only be kept clean and healthy by the assiduous labour of a well-trained, industrious wife, as any one who has paid the least attention to the subject is aware. This is overlooked in Lancashire, where the woman is often engaged in labour from home. The consequence is, that thousands, not only of the children, but of the men and women themselves, perish by the diseases formerly so fatal, for the same reasons, in barracks, camps, gaols, and ships." The children, however, from being most susceptible to the causes of disease, are by far the greatest sufferers. "How pitiful," exclaims the Registrar of Deansgate, Manchester, "is the condition of many thousands of children born in this world! Here in the most advanced nation in Europe—in one of the largest towns in England—in the midst of a population unmatched for its energy, industry, manufacturing skill—in Manchester, the centre of a victorious agitation for commercial freedom—aspiring to literary culture—where Percival wrote, and Dalton lived—13,362 children perished in seven years over and above the mortality natural to mankind! These 'little children,' brought up in unclean dwellings and impure streets, were left alone long days by their mothers, to breathe the subtle, sickly vapours—soothed by opium, a more 'cursed distillation' than 'hebanon'—and, when assailed by mortal diseases, their stomachs torn, their bodies convulsed, their brains bewildered, left to die without medical aid—which, like Hope, should 'come to all'—the skilled medical man never being called in at all, or only summoned to witness the death, and sanction the funeral."*

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* Report of the General Board of Health on Quarantine, 1849, p. 15. These statements have since been confirmed by the official report drawn up by Dr Buch.

* Ninth Annual Report, p. xxiv.

It is evident that no external sanitary measures can effectually grapple with an evil so widely spread and so deeply rooted. *The people must be educated*—be taught to know and to perceive the value of hygienic rules. Till this be done we shall look in vain for any well-founded and permanent amelioration of their condition. So long as the mortality of a densely populated town is, in proportion, double that of the country, and so long as epidemics ravage cities, leaving rural districts almost unscathed, no rational doubt can be entertained that such differences are not mere caprices of nature, but depend on causes which it is in our power in a great measure to remove.

"It must now be considered as an established truth in science," says Dr Sutherland, in advocating views similar to those above expressed, "that the health, well-being, and the duration of the life of man, are intimately connected with the observance of the natural laws of the universe in which he dwells. The acknowledgment of this fact is not, however, sufficient to ensure obedience to these laws. Men must be taught individually and collectively to obey them; each man for himself; every family, in order to ensure its possession of that immunity from disease which the great Creator obviously intended his creatures to possess; and all men acting in their social or corporate capacity for the protection of each other, and of the entire community.

"There is a free choice given. On the one hand there is obedience and health, with all the numberless blessings and privileges which go with it; on the other there is neglect and its infallible consequences, which no human power can fully avert when they are entailed, and these are disease, death, pauperism, loss of property, ignorance, debasement, crime.

"The social evils of this neglect are at present ramified throughout the entire framework of society. A vast amount of property has grown up in all parts of the country, of which it is not too much to assert that it is as productive of misery to the people, as it is unproductive of legitimate revenue to the proprietor. Large masses of population are congregated together without any attention to those conditions on which their health's existence depends, and until very recently it was denied that there were any special causes of disease which occasioned a greater mortality in towns than was the common lot of the human race. Melancholy experience has however proved that unless a very different view be taken of those new duties which devolve on all men, by the very act of their social union, and suitable means of protection adopted, our country will exhibit a progressive descent in the health and productive power of its people, and a corresponding degradation in their moral and social condition, of which, indeed, a low sanitary state must now be considered as an almost invariable exponent."*

But education alone will for a time prove an insufficient remedy. The damp cellars, the narrow alleys, and unventilated courts, must be removed, and houses provided, to which the blessings of light and air may be fully admitted; and if private enterprise be insufficient to effect this change, it becomes the duty of the municipal corporations, as Parliament has now acknowledged, to undertake the work. The capital invested will, as the experience of the model dwelling-houses has already proved, yield a fair return; while the indirect saving to the rate-payers will be great, and the relief of human misery incalculable. In one small court in the city of London, containing about 150 inhabitants, seven persons, including two heads of families, were cut off by cholera, leaving twelve orphans as a burden on the parish, equivalent, it was calculated, to a pecuniary loss of £420. In what the misery consists, the following paragraph from Mr Simon's first Report to the Commissioners of Sewers for the city of London, forcibly points out:—"Scrofula more or less completely blights all that are born, often extinguishing life prematurely; in childhood by hydrocephalus—in youth by pulmonary and renal affections, which you read of as consumption and dropsy, often scarring and maiming when it does not kill, and rendering life miserable by blindness, decrepitude, or deformity; often prolonging itself as an hereditary curse in the misbegotten offspring of those who under such unnatural conditions attain to maturity and procreation."

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* Ninth Annual Report, p. xxv.

* Appendix A to the Report on the Cholera of 1848-9, by the General Board of Health, p. 3.

But such is the ignorance of the mass of the people, and their consequent indifference towards these causes of disease, that it is a matter of the utmost difficulty to convince them of the deleterious influence of agents which are destroying their neighbours in scores before their very eyes; and it is almost inconceivable how speedily the remembrance even of the most fearful epidemic attacks is forgotten, and the sanitary precautions, which were induced by the fright of the moment, are again neglected.

One among many striking instances of this lamentable truth, given in the Report of the Board of Health on Cholera, is the following: A small district of Bristol, measuring 1850 square yards, was so imperfectly drained that the effluvia from the gully grates were at times most horrible. In this confined space, containing 61 small houses, there occurred 89 cases of cholera and 36 deaths; and yet, says Dr Sutherland, "notwithstanding the terrible warning given in this case, and the temporary measures adopted at the time, I learn from Mr Clark's report on Bristol, which I have seen while this sheet is passing through the press, that within twelve months after the catastrophe every thing has reverted to its old condition, and were cholera to recur it would find its former haunts ready to receive it."*

Smallpox is another scourge which annually carried off its thousands, and from which modern science in a great measure protects us; although half a century ago any one should have ventured to express such an expectation, would have been ridiculed for his credulity. Even before Jenner's discovery of vaccination, the improvement of medical science, consequent on increased knowledge of the structure and functions of the human body, had greatly mitigated the fatality of smallpox. Formerly the patients were shut up, loaded with bed-clothes, in heated rooms from which every particle of fresh air was excluded; and stimulants were administered, as if on purpose to hasten the fate of the sick. But sounder views of the wants of the animal economy at last prevailed; and, by the admission of fresh air, the removal of everything heating or stimulating, and the administration of cooling drinks and other fit remedies, thousands were preserved whose lives would have been lost under the mistaken guidance of the older physicians.

So lately as the middle of last century, ague was so prevalent in many parts of Britain where it is now unknown, that our ancestors looked upon an attack of it as a kind of necessary evil, from which they could never hope to be delivered. In this instance, also, farther experience has shewn that Providence was not in fault. By draining the land, removing dunghills, building better houses in better situations, and obtaining better food and warmer clothing, it appears that generations now succeed each other, living on the very same soil, without a single case of ague ever occurring, where, a century ago, every man, woman, and child, was almost sure to suffer from it at one time or other of their lives; thus again shewing how much man may do for the preservation of health and the improvement of his condition, when his conduct is directed by knowledge and sound principles.

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* Appendix A, p. 26.

All experience shews that too much importance cannot be ascribed to the purity of the atmosphere; for a small degree of impurity constantly acting on the blood by means of the never-ceasing function of respiration, is sufficient in the end to produce a morbid condition of that fluid. The source of impurity may be exhalations from the soil, or so bad a construction of our houses, that fresh air is excluded, while the exhalations of the animal body are confined and condensed. Intermittent and remittent fevers generally owe their origin to the former cause; typhus fever, scrofula, and consumption, most frequently to the latter. The chemical nature of these corrupting principles of the atmosphere has not yet been ascertained by direct analysis, but too many facts, deduced from the history of disease, proclaim their existence. It is certain, however, that they are due to the decomposition of organic matter; and hence the primary necessity, in striving to improve the health of a district or city, of removing all the causes which favour such decomposition. Heat and moisture are highly conducive to it, and accordingly, whenever these are present along with dead animal or vegetable substances, an atmosphere loaded with unhealthy exhalations is inevitably produced. "It is well known," says the Registrar-General, "that the decaying matter of marshes gives rise to agues, dysenteries, and fevers; and it is proved satisfactorily by the facts collected under the Registration Act, that the excessive mortality from disease of the zymotic (epidemic and contagious) and other classes, observed in towns, is occasioned by animal or vegetable poisons, with which the atmosphere is charged, in different degrees of concentration, depending on accumulated rowding in dwellings and work- closeness of courts, imperfect supplies of water, and the want of efficient sewers. From these causes the deaths are nearly twice as numerous in ill-constructed towns, where the poison is concentrated, as in the country, where it is diluted and destroyed by the fresh air." The precise degree of influence which the various agencies have in causing the high mortality of towns, is not easily determined. Opinions differ as to what fraction of the suffering and death is to be set down to the want of water or of sewerage, crowded lodgings, narrow streets, ill-ventilated workshops, the destitution of skilful medical advice, the neglect of children, doses of opium and overflowings of quackery, slaughter-houses, and rank churchyards;* but as similar differences of opinion formerly existed as to the causes of the ill-health and inefficiency of the navy, which we shall presently notice, the question of the amount of each individual influence is shewn to be of no practical importance. The work of amelioration must be directed against one and all.

The same causes everywhere produce the same results; and the following extract from the *Report on Quarantine*, by the General Board of Health (p. 86), will shew how certainly, whether on sea or land, disease and death follow habitual neglect of the laws of health:—

"In the larger vessels in which well-directed care has been exercised," says the Report, "the general ill-health has been reduced below the average ill-health of populations of the like ages on shore; but from the evidence which has been brought before us from witnesses at the ports, medical men well acquainted from long practice in the mercantile marine, it appears that the *general* condition of merchant-vessels, and of the forecastles in which common seamen are, for the most part, lodged, renders them in effect cellar-dwellings, just as dark, foul, and unventilated, as the filthy, unaired, and dismal cellars on shore with which the legislature has endeavoured to deal. It appears, also, that typhus and other epidemic diseases do break out at sea in these movable cellars, just as they do in the cellars of the dirtiest courts on shore; and were it not that seamen work in a purer external atmosphere, that they are below decks comparatively for short intervals only, and that, in general, they are men at the most robust periods of life, it is probable that epidemic disease would be still more frequent among them; an inference supported by the fact, that whenever passengers, emigrants, and others, are, owing to stormy weather, much confined to the berths below, some form of malignant disease is almost sure to break out."

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* Ninth Annual Report, p. xxx.

This state of matters has at length attracted the attention of the legislature, and in the session 1849-50 an act was passed for improving the condition of the Merchant Service. It includes a provision for the ventilation of that part of the ship occupied by the crew.

Since the middle of last century a great improvement has taken place in the condition of the crews of the British navy, in consequence of increased attention to sanitary arrangements. To be convinced of this we have only to compare the condition of our seamen in maritime expeditions undertaken a century ago, with their lot in the present day;—Vernon's expedition against Carthagena, or that of Anson, for instance, with those of Cook, Parry, and Ross; or the health enjoyed by the crew of the Valorous, with that of the seamen in the other vessels lying in the same harbour.*

Anson set sail from England on 13th September 1740, in the Centurion, of 60 guns and 400 men; accompanied by the Gloucester, of 50 guns and 300 men; the Pearl, of 40 guns and 250 men; the Wager, of 28 guns and 160 men; the Tryal sloop, of 8 guns and 100 men; and two victuallers, one of 400, and the other of 200 tons. They had a long run to Madeira, and thence to the coast of Brazil where they arrived on the 18th December; but by this time the crews were remarkably sickly, so that many died, and great numbers were confined to their hammocks. The commodore now ordered "six air-scuttles to be cut in each ship, to admit *more air between the decks*," and took other measures to correct the "noisome stench on board," and destroy the vermin—which nuisances had become "very loathsome;" "and, besides being *most intolerably offensive*, they were doubtless, *in some sort*, productive of the sickness under which we had laboured." Such is the mild language used by the chaplain Mr Walter, in communicating these appalling truths! On anchoring at St Catharine's, 80 patients were sent on shore from the Centurion alone, of whom 28 soon died, and the number of sick increased to 96. Although this was nothing compared to what took place afterwards, it is nevertheless worthy of remark, for as yet they had suffered no privations or unusual hardships, except from contrary winds. The causes of disease lay entirely within themselves.

After a stormy and tedious navigation of three months round Cape Horn, scurvy carried off 43 more in the month of April, and double that number in May 1741. Those who remained alive now became more dispirited and melancholy than ever; which "*general dejection added to the virulence of the disease, and the mortality increased to a frightful degree.*" On 9th June, when in sight of Juan Fernandez, the debility of the people was so great, that, 200 being already dead, the lieutenant could muster only two quarter-masters and six foremast men able for duty in the middle watch; so that had it not been for the assistance of the officers, servants, &c., they would have been unable to reach the island—to such a condition was a crew of 400 men reduced in the course of a few months!

I have noticed the cutting of holes for the admission of air between decks, and the dejection of the men. The narrative proceeds to say, that the commodore's principal attention was now devoted to getting the sick on shore, as they were dying fast on board, "the distemper being doubtless considerably augmented *by the stench and filthiness in which they lay; for few could be spared to look after them, which rendered the ship extremely loathsome between decks.*" The officers suffered least, as being the best fed and best lodged. Within a year, out of upwards of 1200 men, composing the crews of the squadron, who had sailed from England, only 335 remained alive.

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* See p. 63.

The fate of the Spanish squadron, which sailed nearly at the same time, was still more horrible. The Esperanza, of 50 guns, lost 392 out of 450 men, and the other ships almost as large a proportion. It is true that, in doubling Cape Horn, they encountered the severest weather and the greatest privations, and that their deplorable fate was aggravated by these causes. But when we look to the history of later navigators, in circumstances equally trying, it is impossible to resist the gratifying conviction, that mortality like this forms no part of the designs of a beneficent Providence, and that, for the best of purposes, our safety is placed to a great extent within the limits of our own power. The late memorable expeditions of Parry, of Franklin, and more especially of Sir John Ross, who, with few resources, spent upwards of four years in the desolate regions of the north, with scarcely any loss of life, are examples pregnant with meaning to all who are interested in the future progress of man.

It may be said that the climate and the situation of the two parties were dissimilar, and that Anson's men were less healthy at the commencement of the voyage. In some respects, the objection is well founded; but Cook's second voyage round the world, in 1772, affords a parallel presenting so many points of resemblance to that of Anson, that no one can reasonably object to their comparison. On this occasion, the vessels selected were the Resolution, carrying 112 men, and the Adventure, with a crew of 81. Enlightened by former experience, Cook spared no pains to effect his equipment in the completest manner, and to lay in such stores of clothing and provisions as he knew to be useful in preserving the health of those under his command. Among these were malt, sour krout, portable broth, sugar, and wheat. Care was taken to expose the men to wet as little as possible, to make them shift themselves when wet, and to *keep their persons, hammocks, bedding, and clothes, perfectly clean and dry.* Equal attention was paid to keep the ship clean and dry between decks; once or twice a-week it was aired with fires; and a fire was also frequently made at the bottom of the well, which was of great use in purifying the air in the lower parts of the ship. To the last precaution too great attention cannot be paid, as the least neglect occasions a putrid and disagreeable smell below, which nothing but fires can remove. Fresh water, vegetables, and fresh provisions, were also eagerly sought for at every opportunity; and these it was Captain Cook's practice to oblige his people to make use of, by both authority and example. The results of these measures we shall now see.

The two ships sailed on 13th July 1772. About the end of August, "when advancing towards the south, the rain poured down, not in drops but in streams; and the wind at the same time being variable and rough, the people were obliged to attend so constantly upon the deck, that few of them escaped being completely soaked." But although rain is a great promoter of sickness in warm climates, the airing by fires between decks, and the other precautions, were so effectual, that, on arriving at the Cape of Good Hope, *only one man was on the sick list;* whereas we have seen that after a similar voyage, the Centurion arrived on the coast of Brazil with 80 sick, of whom 28 soon died. As we proceed the contrast becomes still more striking. On 22d November Cook sailed from the Cape in search of a southern continent. On the 29th a violent storm, attended with hail and rain, came on and caused the loss of most of their live stock; and a sudden transition took place from warm and mild to extremely cold and wet weather, which was severely felt by the people. On 10th December they met with islands of ice; and, from that time till the middle of March, continued their search for land with unremitting diligence, amidst cold, hardships, and dangers, such as we can form but an imperfect idea of; and, at last, on 26th March, *after being* 117 *days at sea*, during which they had sailed 3660 leagues, they came to anchor in Dusky Bay, New Zealand. "After so long a voyage in a high southern latitude," says Dr Kippis, from whose Life of Cook these particulars are taken, "it might certainly have been expected that many of Captain Cook's people would be ill of scurvy. This, however, was not the case. So salutary were the effects of the sweetwort and several articles of provision, and *especially of the frequent airings and sweetening of the ship*, that there was only one man on board who could be said to be much afflicted with the disease; and even in that man it was chiefly occasioned by a bad habit of body, and a complication of other disorders."

Can any thing be conceived more demonstrative of the advantages to be derived from investigating and obeying the laws of health, than these splendid results, when contrasted with those on board of the Centurion? In the Resolution, cheerful activity, cleanliness, dry pure air, adequate clothing, and a suitable regimen, were found to carry men unscathed through hardships and exposure which, in the Centurion, from neglect of the same protective means, were allowed to sweep off a large proportion of the crew. And, as if on purpose to place the efficacy of these measures beyond a doubt, it appears that, in the month of July 1773, the Adventure had many sick, and twenty of her best men incapable of duty from scurvy and flux; while the Resolution, with a larger crew, had not more than three men sick, and only one of them from scurvy. This difference in the state of health of the two ships was distinctly traced to the crew of the Adventure having eaten few or no vegetables when in Queen Charlotte's Sound; while, on board of the Resolution, Cook was most particular in enforcing attention to this part of their dietetic regimen.

By this admirable care and unwearied watchfulness on the part of Cook and his officers, the Resolution performed a voyage of THREE YEARS and eighteen days, *through all climates* from 52° north to 71° south, with the loss of only ONE man by disease out of 112. And in his last voyage, so efficaciously were the same means put in practice, that his ship was brought home after an absence of FOUR YEARS, without the loss of a single man by disease.

Lord Nelson is said to have been equally successful, and to have spent three years on the West India station without one life having been lost by disease.*

Similar results were obtained by the able commanders of our more recent expeditions to the Arctic Regions. The Fury and Hecla were, at one time, no less than *twenty-seven months entirely dependent on their own resources*, before scurvy began to make its appearance; and at the end of 28½ months both ships returned home (in September 1823) with the loss of only five men—a result which, a century ago, could not have occurred; and which, even at the present day, is a remarkable indication of the talent and humanity of the officers by whom it was effected.

Nothing, in fact, could have been better devised than the means practised in these expeditions to preserve the health of the people; and did my limits permit it, I might illustrate almost every principle expounded in this volume by a reference to its actual efficacy as displayed in these voyages. Not only were the conditions of health attended to as regarded the skin, the muscles, the bones, the lungs, and the digestive organs, but the health of the all-important nervous system was seduloualy provided for by the constant and cheerful occupation of the people in their various duties and amusements; and so judiciously were these planned, that a spirit of life and activity extremely favourable to the preservation of health was constantly kept up, and had, no doubt, great influence in producing that concord and unity of feeling among them, which was so conspicuous amidst all their privations.

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* Sir George Ballingall's Lect. on Milit. Surg., p. 73.

The beneficial influence of these various particulars is also well exemplified by the experience of Lord Collingwood. In a letter to his wife, dated, Ocean, off Toulon, May 15, 1808, he says: "I have been long at sea, have little to eat, and scarcely a clean shirt; and often do I say, Happy lowly clown. Yet, with all this sea-work, never getting fresh beef, nor a vegetable, *I have not one sick man* in my ship. Tell that to Dr ——." His biographer adds: "The attention which Lord Collingwood paid to the health of his men has been already mentioned; but it may be added here, that in the latter years of his life he had carried his system of arrangement and care to such a degree of perfection that perhaps no society in the world of equal extent was so healthy as the crew of his flag ship. He had usually 800 men; was on one occasion more than one year and a half without going into port, and during the whole of that time never had more than six, and generally only four, on his sick list. This result was occasioned by his attention to dryness (for he rarely permitted washing between decks), to the frequent ventilation of the hammocks and clothes on the booms, to the creation of as much circulation of air below as possible, to the diet and amusement of the men; but, above all, to the contented spirits of the sailors, who loved their commander as their protector and friend, well assured that at his hands they would receive justice and kindness, and that of their comforts he was more jealous than of his own."*

It is certainly most satisfactory (as Sir Gilbert Blane remarks in one of his instructive dissertations) to contemplate the many proofs we have of the substantial benefits that have accrued to the sea-service in the last forty years, both in war and commerce, in all quarters of the world, from the zeal, humanity, and good judgment displayed in promoting the health of seamen. *It has been proved that it has added at least one-third to the national force, and therefore subtracted in the same proportion from the national expenditure.* . . . . . And on a review of this subject, in all its extent and relations, it will appear that there is not probably to be found in the whole range of human affairs a finer illustration of the practical benefits of progressive knowledge in promoting the great interests of mankind; so that science, while it lends an aid, also sheds a grace and dignity over the useful arts; nor can there be a more striking proof of the maxim, that humanity, like every other moral virtue, is the best policy; nor could we light on a more happy example to elucidate that subsidiary influence and mutual dependence, by which all the arts, sciences, and professions have a mutual bearing on each other, conspiring to bring about the greatest sum of human enjoyment, and affording a field of contemplation in which cultivated, benevolent, and pious minds delight to expatiate."*

If, from these examples of the power of skilfully applied knowledge we turn, for a contrast, to the extraordinary prevalence of disease at the Millbank Penitentiary in 1823–4, we shall see the opposite side of the picture, and discover how much misery may flow from the unintentional neglect of sound physiological principles in some of our civil institutions. At the time spoken of, intractable affections of the bowels, and other insidious forms of disease, were so general in the penitentiary, that few of the prisoners escaped; and a parliamentary inquiry into their causes was ordered. Great discrepancy of opinion prevailed, as usual, among the witnesses, from each giving utterance rather to his own impressions than to opinions founded on any philosophical examination of the circumstances. But evidence enough was brought forward to shew that several great errors had been committed. In the *first* place, the penitentiary itself was built, at an enormous expense, in a *low damp situation*, somewhat under the level of the highest tides in the Thames; so that the supply of dry pure air is always imperfect, and the atmosphere at night is often heavy and damp, as on all low grounds in the neighbourhood of rivers and half-covered mud. To this great and permanent source of debility were added, *secondly*, a very low and inadequate diet; and, *thirdly*, the influence of constant mental depression, arising partly from the local situation of the prisoners, and partly from the monotonous confinement and labour under too scanty a supply of food. In such circumstances, it certainly was not wonderful that a low state of health, and latterly scurvy and bowel-complaints, should make such general havoc.

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* Correspondence and Memoirs of Lord Collingwood, vol. ii., p. 119.

* Dissertation on the Comparative Health of the British Navy, from the year 1779 to the year 1814, in Select Dissertations, p. 36.

That much of the sickness was justly attributable to these causes, is shewn by the perfect immunity enjoyed for some years, both by the officers of the penitentiary and by about thirty of the prisoners, who, from being employed in the kitchen and offices of the establishment, were less subjected than the rest to the debilitating influence; and also by the rapid convalescence of almost every one out of 635, when removed to Woolwich and the Regent's Park, and supplied with a more nourishing diet. On more minute inquiry, indeed, it appeared that, instead of the bad health having suddenly begun in 1823, as at first supposed, bowel-complaints had been extremely prevalent from the first opening of the penitentiary in 1816, and had continued to be so, though in a rather less degree, down to that time; so that the causes must have been inherent in it from the beginning, and only became aggravated by the farther reduction of diet which took place some months previously, and by the inclemency of the weather.

This opinion has been corroborated by subsequent experience, which has shewn that the inmates of the penitentiary habitually suffer from ill health in a much greater degree than those of the other prisons of London, and that epidemics fall upon them with peculiar force. In 1848–49 the population of all the prisons of London amounted, on an average, to 4358, of which number 1006 were in the penitentiary, 800 in the Westminster House of Correction, and the remainder in the other prisons. During the cholera epidemic of these years the number of cases in the penitentiary was 113, and the number of deaths 48; and in the House of Correction they were respectively 42 and 13. In the remaining prisons, the average population of which was 2452, there occurred three cases and one death. The chief, if not the sole cause, of this great difference of disease and mortality appears to have been in the condition of the atmosphere. The House of Correction, like the penitentiary, lies low, and suffers, though not to an equal extent, from the exhalations of the river and the impurities from the manufactories in the Borough.* This atmospheric impurity was aggravated, especially in the case of the Penitentiary, by overcrowding and deficient ventilation; for a better state of health immediately supervened when the number of inmates was diminished.†

The prejudicial influence of impure external air is more remarkable in warm climates than in our own, owing to the greater rapidity with which organic matter decomposes under the action of heat. But it has been frequently observed with wonder, as an exception to the general rule, that persons living near the source of impurity have been unharmed, while others at some distance have been attacked with fever. Thus, in the West Indies, barracks have been erected at great expense in high and open situations, in the expectation that they would prove remarkably healthy, but which, to the surprise of the projectors, have turned out quite the reverse; the troops occupying them being frequently decimated by disease, while the inhabitants of the lower lying country escaped. In like manner, as Dr Herbert Mayo[*] has observed, "the neighbourhood of Versailles is powerfully influenced by the marshes of St Cyr; and at Neuville-des-Dames, above Chatillon on the Indre, fevers are more prevalent than those close to the marshes where malaria is produced. The most extraordinary instance of the kind known is mentioned by Dr Macculloch to occur at Malta; the malaria, which is originated on the beach below a cliff, produces no effect on the spot itself, while it affects, even to occasional abandonment, the village situated above."

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* The sanitary condition of the House of Correction is likely to be ameliorated by the improvements now (1851) being carried on in its neighbourhood.

† For further details see Appendix B to Report of Board of Health on Cholera of 1848-49, p. 64.

The question is one of considerable importance, as its complete elucidation would be of great service in preventing future errors, and in saving many valuable lives. It is thus treated by Professor Caldwell, who has had many opportunities of studying the subject:—"I have been often asked the reason why elevated points on the banks of the Mississippi are more unfavourable to health than low ones? The problem is difficult of solution; and the reply to the question must be at best *conjectural*. Between malaria and water, especially in the forms of mist and dew, there appears to be a strong affinity. During the day that poison rises from the margin of the river so gradually, and in such a state of dilution, as to do no injury to those on the lower ground. Having reached the summit of the height, and the coolness of evening and night having come on, it is then condensed and precipitated in greater concentration with the dews, which fall most copiously if not alone on the high places, and thus sickens those with whom it comes in contact. For it is known to be chiefly at night that it strikes and does mischief. Hence one cause of the danger of exposure during *late hours*. Meantime, those who reside at the base of the bluff, or but a short distance up its side, are visited by the miasm in a much less concentrated condition, and hence escape its deleterious effects. For the same reason disease prevails on the high ground constituting the banks of ravines, in which water stagnates or runs slowly. This attempted solution of the problem is offered for only as much as it may be deemed worth; and I am ready to surrender it in exchange for a better, as soon as it shall be presented to me. Somewhat, however, in corroboration of this solution, a gentleman, who is a very close and accurate observer, has told me, that, at night, when the atmosphere on the heights was so cool as to be *depositing its dew*, he has felt the warm air from below ascending the sides of the bluffs and ravine-banks, on account of its greater levity; and that, on reaching the top, it became chilled, and precipitated its humidity also."[*]

With reference to the powerful effect of the state of the mind on the health, in the case of the prisoners removed from the Millbank penitentiary to Woolwich, Dr Latham has given striking evidence. Speaking of the women who were sent on board of one of the hulks, he says that individuals were pardoned from time to time for good conduct, and that recently pardons had become very numerous, as a kind of atonement for the bad health to which they had been subjected. But, as all had nearly an equal claim, "every one pleased herself with believing that she would be the next who would be set at liberty. Whenever, therefore, an individual was pardoned, all the rest *were thrown into an agony of the bitterest disappointment, and were at the same time overtaken by disease.* It was not a mere nervous or hysterical ailment, but *some actual form of real disease, such as they had before suffered*, and requiring the strictest medical treatment for its relief."*

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[*] Philosophy of Living, third ed., p. 212.

[*] Thoughts on Hygiène, by Charles Caldwell, M.D., p. 85.

An instructive instance of the manner in which life is occasionally sacrificed through ignorance, notwithstanding long-continued efforts to ascertain the cause of the mortality, has recently been made known from the experience of the Lying-in-Hospital of Vienna, and promises to be most useful in checking the ravages of a malady, which, in times past, has frequently raged as an epidemic, carrying desolation into homes at the very moment when the dearest hopes seemed about to be realized. We speak of puerperal fever. For many years it had been remarked, that the proportion of deaths in the Maternity Hospital of that city was greatly in excess of that which took place in private practice; and several government commissions had been at intervals appointed to investigate the cause, but without success. At last, on the patients being divided into two classes, one of which was attended by the students of the university, and the other by females who were being educated as midwives, it was remarked with astonishment that the mortality in the first class so greatly surpassed that in the second, that in about an equal number of deliveries the proportion of deaths stood as 600 to 32.†

Guided by this astounding fact, M. Semelweis guessed that the cause must somehow be connected with the attendants, for in this particular only the two classes differed. He saw that the students, in the prosecution of their studies, spent much of their time in the dissecting-room and in the wards of the hospitals, and were thus constantly brought in contact with decaying animal matter; while the midwives were not exposed to these sources of contamination. Immediately a flood of light poured in upon his mind as to the cause of the disease, and orders were consequently given that no student should be admitted into the Maternity Hospital without washing his hands in a solution of the chloride of lime, using a nail-brush, and taking every precaution to free himself from animal impurities. These measures succeeded to admiration—the mean mortality falling from 10·70 per cent. to 1·27.

In July 1847, the Maternity Hospital of the University of Kiel was closed on account of the ravages of puerperal fever, and had scarcely been reopened in November, when the disease again appeared. It was about to be closed a second time, when intelligence of the precautions taken at Vienna reached Kiel. They were immediately adopted, with success so decided, that no case afterwards occurred.*

It is well known that sometimes a fatality appears to attend a practitioner, and that he loses several cases from puerperal fever in rapid succession. The facts now quoted may indicate the cause, and ought deeply to impress every medical man with the responsibility which must attach to him, if, from the neglect of due purification, he carries from patient to patient the seeds of so intractable a malady. It appears to be produced by the introduction into the system of corrupt animal matter, which may be derived either from the diseased living body, or from one already dead. Hence practitioners of this branch of the medical art should guard against every possible source of contamination, and not merely adopt precautions when they have been engaged in the treatment of a puerperal case.

In looking forward to a still greater diminution of disease in the human family, it is cheering to fix attention on what has been already accomplished by the hand of authority. Had the same individuals who circumnavigated the globe with Cook, or braved the northern winters with Ross and Parry, been left for an equal number of years to undergo the ordinary vicissitudes of life at home, unrestrained in their inclinations and conduct by the constantly operating and beneficent influence of a superior mind, it is morally certain that disease and death would have made greater havoc among them than was actually the case amidst physical privations and sufferings much greater than they were likely to have ever encountered at home. This, then, is additional evidence of the pressing necessity of diffusing widely among society that species of knowledge which has proved so beneficial in the hands of those who were fortunate enough to possess it. If human health and happiness be thus effectually promoted by increased attention to the conditions which affect the vital and animal functions, nothing can be more useful than to communicate to every intelligent being such a measure of knowledge as will enable him to do for his own safety and improvement that which the Government now does for the benefit of those whose services it requires.

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* Account of the Disease lately prevalent at the General Penitentiary, by Dr Latham, p. 192.

† Brit. and For. Med.-Chir. Rev., Jan. 1850, p. 274.

* Annales d'Hygiène, April 1851, p. 286.

It cannot be too much impressed upon the mind, that health is the natural and intended condition of the human body, and that all deviations from this state must arise from causes having their origin in human ignorance or neglect; disease being the evil consequence attached by an all-wise Creator to wilful or ignorant disregard of those laws which have been established by Him as essential to human health and happiness.*

Even countries which are esteemed unhealthy by Europeans owe their bad character, in no small degree, to an ignorant deviation from the habits of the natives. "The climate of India," says Colonel Sykes, "is less to blame than individuals; for in case foreigners find the people in a country healthy, they should to a certain extent conform to the habits of the natives to be healthy also."*

When Dr Daniell visited the Rio Formosa, in 1839, he found two vessels moored a short distance from its mouth, one of which, within the space of five months, had buried two entire crews, a solitary person alone surviving; the other, which had entered it at a much later period, had been similarly deprived of one half of its men, and the remainder were so debilitated as to be incapable of undertaking any active or laborious duty. After a stay of several weeks, the ship to which he was himself attached became so unhealthy, that it was necessary to recross the bar into a purer atmosphere, the ship having lost one-third out of a complement of eighteen men. "And yet," says Dr Daniell, "amid these regions so rife with disease and death, I have known Europeans reside for a number of years in the enjoyment of good health, from the simple secret of moderately conforming to the habits of the natives as regards the diet, exercise, and attention to the due performance of the cutaneous functions."†

The natives of India are proverbially temperate, and in the following example we find the benefit of imitating them in this respect well illustrated by the experience of the 84th Regiment of H.M. Foot, which, moreover, has for some time enjoyed a high reputation for good moral conduct. During the first eight months of the year 1846-7, the regiment was quartered at Fort St George, Madras; it then performed a march of between 400 and 500 miles, to Secunderabad, in an unusually wet season, the roads being in some parts covered knee-deep with water. The medical return of the regiment for the year gives, for these circumstances, the almost unprecedentedly low number of thirteen deaths in an average strength of 1072

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* On this subject, see Brit. and For. Med.-Chir. Rev., January 1850, p. 223.

* Journal of the Statistical Society, vol. x., p. 124.

† Sketches of the Medical Topography and Native Diseases of the Gulf of Guinea, p. 60. Lond. 1849.

[illegible] being at the rate of 1·21 per cent.; whereas the average mortality of all the European troops in the Presidency was 4·21 per cent. During the year that the regiment remained at Secunderabad (1847–48) its mortality was less than half the average rate at that station for fifteen years previously. These remarkable facts are ascribed to the abstinent habits of the soldiers, a large proportion of them being teetotallers, and those who were not so being very moderate in their consumption of alcoholic liquors.*

With these successful and cheering results of knowledge, it will be instructive to contrast another instance of the fatal effects of ignorance in a situation where knowledge might have been effectual in preserving life and sparing suffering. I shall take the example from an early publication of Dr James Johnson,† who devoted no small amount of attention to the subject of health and the causes by which it is affected, and whose work contains much valuable matter connected with hygiène, as well as with the history and cure of disease. In treating of exercise, and the evils of its excess, Dr Johnson says—"I shall exemplify this reasoning by an instructive lesson. During the late war, it was observed, that, in its earlier periods, fever, fluxes, and scurvy, made the greatest havoc; while in its middle and ulterior periods, these diseases almost disappeared, and pneumonia (inflammation of the lungs), with its too frequent consequence, PHTHISIS, became infinitely more prevalent and fatal. The facts were apparent to all, but the causes few could divine. Some of our chemical wiseacres attributed the pneumonic diathesis to the lime-juice served out; but this hypothesis need not detain us, for I think a more rational explanation can be offered. As the period of warfare was lengthened out, discipline gradually became more perfect, and at length attained its acme. Every evolution was now performed with a rapidity and precision that seemed the effect almost of magic. All machinery and apparatus were not only so arranged as to give human power its greatest force and facility of application, but human strength was put to its ultimatum of exertion, and every muscular fibre of the frame called into furious action, during each manœuvre of navigation or war. Thus, in exercising the great guns, the heaviest pieces of artillery were made to fly out and in, or wheel round, with almost the celerity of a musket in the hands of a fugleman. The most ponderous anchors were torn from their beds with astonishing velocity; while the men were often seen lying about the decks breathless and exhausted after such ultra-human exertions!

"But reefing and furling sails were still worse. Here, as in all other operations, there was a constant struggle against time. The instant that the word '*aloft*' was given, the men flew up the shrouds with such agility, that by the time they were on the yards, the respirations were nearer fifty than fifteen in a minute! In this state of anhelation they bent across the yards, and exerted every atom of muscular energy in dragging up the sails and securing the reef-lines, while the thorax was strained and compressed up against the unyielding wood! What were the consequences? The air-cells were frequently torn, blood extravasated; and the origins of cough and hemoptoës (spitting of blood) continually laid. The lungs were now in a proper state for receiving the impression of aërial vicissitudes; and constant exposure to night air, to rain, and every inclemency of the season, soon *evolved the long black catalogue of pulmonic and phthisical maladies, which swept off our men in vast numbers, to the no small surprise of the officers, who could not divine the cause of this new and destructive enemy.*

"But it was not the lungs alone that suffered here. The central organ of circulation bore a part of the onus, and a host of anomalous and otherwise inexplicable symptoms were produced, which completely puzzled the naval practitioners, who rarely suspected any lesion of the heart. These last affections both aggravated, and were in their turn aggravated by, the depressing passions engendered during the long confinement on ship-board, and separation from friends and native home."

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* Brit. and For. Med.-Chir. Rev., Jan. 1850, p. 92–3.

† On the Influence of the Atmosphere on the Health and Functions of the Human Frame, &c. 8vo, 2d edition, p. 130.

I hardly need to point out how much the fatal results above mentioned might have been prevented, had the officers possessed even a superficial acquaintance with the laws of respiration and of muscular action. A perusal of the chapters on these subjects will enable the reader to judge for himself, and to determine whether the cause of the destruction was really difficult to be divined. It is impossible indeed to read such details considerately, without coming to the conclusion that a general acquaintance with the constitution of the human body ought to be rendered imperative on every one who is entrusted in any way with the direction of, or command over, any of his fellow-creatures. Where so much is necessarily left to individual discretion, the possession of knowledge in aid of sound sense is the only attainable security against abuses. In many situations, some knowledge of the laws of the animal economy would be of the greatest use, not only to the instructors of youth and the guardians of public institutions, but also to the officers of the army and navy. Independently of all other considerations, it would open to them a field of interesting study and observation in every country and under every climate, which could not fail to procure for them a large amount of pleasure and instruction. Dr Johnson, it should be mentioned, had the Channel and North Sea fleets chiefly in view in his remarks.

It was at one time very common to eulogize the simple food and hardy habits of the poor and labouring classes as eminently conducive to health, when contrasted with the debilitating effects of the cares and luxuries of the rich; and to a certain extent the fashion had some foundation in truth. Thus if we institute a comparison between the ages at death of the superior portions of the working-classes (such, for instance, as are members of benefit-societies), and those of the aristocracy, the result appears to be in favour of the former. Mr Neison's tables, which are constructed from the experience of benefit-societies, shew, for example, that an agricultural labourer at the age of thirty, has an expectation of life greater by nine and a half years, than a peer of the same age.* Here "simple food and hardy habits" give a decided advantage over "cares and luxuries;" but the case becomes widely different when the comparison is extended to the rich and poor as great classes of the community. The average period of life among the poor is, in the first place, greatly reduced by the frightful mortality among the children, who, in consequence of their more delicate constitution, suffer more readily than adults from injurious influences, and who may, on this account, be regarded as a sort of sanitary barometer. In the second place, the adults, although less susceptible than children, are unable to resist without injury the debilitating effects of over-crowding and defective ventilation, and of excessive labour in conjunction with deficient or innutritious food. Accordingly it may be shewn by arithmetical arguments, that the excess of work and the privations to which the poor are habitually exposed, produce a much higher rate of mortality among them, especially in seasons of scarcity or commercial depression, than among the richer classes of society. In evidence of this fact, I may refer to a table published by Dr Casper of Berlin, shewing the influence of wealth and poverty upon the duration of human life. He takes from the register of deaths in the Almanack of Gotha a thousand names belonging to the families of princes and dukes, and from the official returns of the population of Berlin a thousand names of persons who had lived upon charity, and whose deaths had been carefully registered. Of a thousand rich and poor there were existing, says he—

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* Brit. and For. Med.-Chir. Rev., January 1848, p. 19. See also Carpenter's Essay on Alcoholic Liquors, p. 86, for the mortality of the members of Friendly and Temperance Societies.

	Rich.	Poor.
At the age of 5 years,	943	655
... 10 ...	938	598
... 15 ...	911	584
... 20 ...	886	666
... 25 ...	852	553
... 30 ...	796	527
... 35 ...	753	486
... 40 ...	693	446
... 45 ...	624	396
... 50 ...	557	338
... 55 ...	464	283
... 60 ...	398	226
... 65 ...	318	172
... 70 ...	235	117
... 75 ...	139	65
... 80 ...	57	21
... 85 ...	29	9
... 90 ...	25	4
... 95 ...	1	2
... 100 ...	0	0

In strict accordance with these facts, it appears, from the returns, that the mortality among the children of the poorer classes in Paris is nearly double that occurring among those in more affluent circumstances; while, in the wealthier departments of France, the average of life is twelve years greater than in those which are poor. Similar results are observed in London, where, according to Dr Granville's tables, only 542 infants out of every 1000 births among the *poor* survive their second year; and both in Paris and in London, the mortality in the quarters inhabited by the working-classes, is proved to be nearly double that which occurs in those inhabited by the more wealthy. The influence of impoverished diet, defective clothing, and unfavourable moral position, is further strikingly exhibited among the children of soldiers, of whom, according to Marshall, only a very small proportion reach the age of manhood; most of them being stunted in their growth, scrofulous in constitution, and bad in morals.*

If such, then, be the disproportion which occurs between the rates of mortality in the different classes of society in Great Britain, it suggests some most important considerations, the first of which is the simple question, Whether that condition of the lower orders can be regarded as eminently prosperous or natural, which subjects them to be cut off by death so many years before the term allotted to those by whom they are employed? It also illustrates, strikingly, what I have said about bad health being more frequently *the result of gradual causes long in unperceived operation*, than of any sudden or accidental exposure; and proves that a mode of life or degree of labour is not to be rashly pronounced harmless, merely because its injurious effects are not immediately seen, and because years may elapse before it breaks down the constitution. It is blindness to the existence of this principle which still misleads mankind, and renders them insensible to the agency of numerous hurtful influences, from which, by a little exertion, they might easily be relieved.

Still it is cheering to observe that, on the whole, the condition of society is steadily improving. We have already mentioned the general decrease of the mortality of London, and may here shortly notice the result of the late researches of M. Ch. Dupin on the longevity of the inhabitants of France. From these it appears that the present average duration of life among all the classes of the French population, is higher than it was in the first half of last century among picked lives taken from the ranks of individuals of independent means.† In these simple facts is chronicled a vast advance in social progress; but still it cannot be denied, that in individual cities and individual districts of cities, the public health has of late years rather deteriorated than improved. Thus we have seen that the late cholera epidemic carried off a larger proportion of victims in London than that of 1832, and the census of 1851 has just shewn that during the last ten years an excessive mortality has prevailed in Glasgow, reducing, along with other causes, the population many thousands below the number which had been calculated.

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* Marshall on Enlisting, &c., p. 16.

† Annales d'Hygiène Publique, April 1849, p. 451.

Much angry discussion has taken place at different times as to the reality of the mischief inflicted by the protracted and unremitting exertion required in our factories and spinning-mills, where an unerring test might easily be found. If those who contend that the hours of labour are not too long for either the children or the adults, could produce evidence to shew that, among operative cotton and flax-spinners, for example, the average of life is equally high as among the apparently more favoured classes, there would be at once and for ever an end of the argument; while, should the result prove different, the system of labour may justly be deemed oppressive, in the precise ratio in which the mortality among the operatives exceeds that among their wealthier countrymen. No criterion can be so infallible as the one here proposed; and as the Government now possesses the means of obtaining accurate returns, it is very desirable that the fact should be tested. In the first two reports of the Registrar-General, a comparison is made between the mortality of town and country districts, which shews the superiority to be greatly in favour of the country. But as no attempt is made to separate the mortality among the manufacturing population from that of the poor generally, data are still wanting to decide the question conclusively. The French returns, however, are more specific, and they afford direct evidence of both diminished stature and an increased mortality as results of the introduction and spread of manufactures; and I wish much it were in my power to lay some of them before the reader. As it is, I can only refer to the excellent work of Villermé on the physical and moral condition of the manufacturing population of France, as a storehouse of valuable information bearing directly upon the question at issue.

Everything which tends strongly to call attention to the conditions which influence public and individual health, is calculated to do great good to the community. In this point of view, I am disposed to consider the visitations of cholera to the British Isles, rather as among those remarkable instances in which a beneficent Providence brings good out of evil, and converts an apparent calamity into a positive blessing, than as the public scourges which they were generally proclaimed to be. True it is that many individuals perished, and that others suffered by it in their affections and in their worldly circumstances; but I question if any thing short of the dread which cholera produced, could have combined all classes so efficiently and ardently in their efforts to discover and remove every thing in the condition of the poor and labouring portions of the community, which could prove detrimental to health. In the season of apparent danger, not only did the importance of cleanliness, ventilation, warmth, clothing, and nourishment, as preservatives of health, become manifest to minds on which nothing else could have made an impression; but their experienced efficacy gave an impetus to the exertions of the lower orders in their own behalf, which, it is hoped, will continue to be productive of good long after the cause from which it sprung shall be forgotten. As yet, however, it must be confessed, this hope has received but little encouragement from any actual deeds. But the lower orders themselves can scarcely be expected to continue exertions which are quickly relaxed by the authorities to whose care the public welfare is committed. "It has already been stated," says Mr Grainger, "that in several parishes, in consequence of the reports either of the inspectors of nuisances or of the visitors, improvements and cleansing operations were effected by the local authorities; but it is proper to explain, it is the concurrent opinion both of the medical inspectors and visitors that these proceedings will not be permanent; and in corroboration of the correctness of this conclusion, I may state that, in most of the parishes where during the epidemic inspectors of nuisances were appointed by the guardians, these officers have since been dismissed. Unless, therefore, some other measures be adopted, it is certain that in the most populous and poor districts a return to the old state of things will speedily, if indeed it has not already taken place."* We have seen above (p. 319) how fully Mr Grainger's fears have been realised at Bristol; and there is too much reason to fear that this apathy will continue till instruction in the laws of health, and training to the habitual observance of them, shall form a part of the education of the people, who can only thus be enabled to apprehend the connection between the causes of disease and its actual appearance. . . . . .

The comparative exemption of the wealthier classes from cholera is itself sufficient to shew how much it is in the power of man, by the proper exercise of reason and the application of his knowledge, to obviate the dangers to which his health is exposed; how closely his bodily welfare is dependent on his own conduct and external situation; and how very little, comparatively, it is the result of circumstances which he cannot control or modify. Never was this truth more strikingly exhibited than during the frightful prevalence of cholera at Kurrachee in June 1846. Within the first three days one regiment lost 184 men, while of all the officers stationed there, only three died during the whole epidemic. The very fact that the officers thus escaped when the men suffered so severely, shews that the causes of this excessive mortality were removable, and that the men might have been protected from them much more than they were. According to the newspapers, continued exposure to intense heat and a moist atmosphere, sheltered only by tents instead of barracks, and the want of wholesome food, were the principal sources of the mortality; and this is rendered the more probable, because both of these are conditions against which the officers would, from their private resources, be much more able to protect themselves than the privates. In strict accordance with this, also, it will be readily admitted by every one who has investigated the subject with attention, that, but for the establishment of soup-kitchens, the supplies of warm clothing, and the whitewashing, cleaning, and ventilating of the houses of the poor, before and during the epidemics, a much greater number would have fallen victims to its ravages. And it is consoling to know, that even those who regard such visitations as direct inflictions of an offended Providence, and as nowise connected with mere neglect of the laws of health, were nevertheless not the least active in enforcing and superintending the removal of every external cause of disease, and promoting the comforts and supplying the wants of the needy and destitute; so that whatever differences in mere belief there might be, all parties were content *to act* as if the Creator had intended the health of the race to depend, in a very high degree, on the care which was taken to fulfil the conditions which He has decreed to be essential to the due action and preservation of the various bodily organs.

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Many individuals exist, who, from hereditary deficiencies, can scarcely attain tolerable health, even with the best care; and many more are to be met with who are exposed to bad health from the hurtful nature of the professions in which they are engaged. Many suffer, also, from vicissitudes of the weather, from the nature of the country they are called on to inhabit, and from other causes which it may never be possible entirely to guard against. But all such sufferers united are few, when compared to the number of those whose health is ruined by causes capable of removal or of modification, and to which they are now exposed from ignorance of their nature, from apathy, or from the want of the comforts and necessaries of life. If I have succeeded in calling attention to this important truth, one great object of these pages will be accomplished; and here I cannot help repeating the remark already made more than once, that *health is more frequently undermined by the gradual operation of constant though disregarded causes, than by any great or marked exposures of an accidental kind*, and is consequently more effectually preserved by a judicious and steady observance of the organic laws in daily life, than by exclusive attention to any particular function, with neglect of all the rest.

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* Appendix (B) to Board of Health's Report on the Cholera of 1848-9, p. 169.

It may be said that I allow nothing for the influence of habit in rendering situations and causes comparatively innocuous, which were dangerous at first. It is quite true that the human constitution possesses a power of adapting itself within certain limits to a change of circumstances; but it is not less true that the constant action of an apparently slight injurious influence is sufficient in the end to sap the strength of the healthiest constitution. The experience of the French army in Algeria, and of our own in the East and West Indies, shews that during the first years the health of the soldiers is better than it subsequently becomes. The mortality increases as the stay is prolonged, and clearly proves that any advantage that may be derived from acclimatisation is more than neutralised by the habits of the soldiery not being in accordance with their altered external circumstances. In the present state of our knowledge it is impossible to say whether, by drainage and other sanitary measures, intertropical countries may be rendered innocuous to the European constitution; but it is a curious fact, and one which existing science is incapable of explaining, that the negro can withstand, comparatively without injury, the noxious action of a climate which proves most fatal to Europeans. This was exemplified during the Niger expedition in 1841 and 1842. The three steamers which were employed, were fitted up with all precautionary means to ensure the health of their crews, which consisted of 145 whites and 158 blacks. Of the latter, 133 were entered on the coast of Africa; the remaining 25 were entered in England, and were natives of the West Indies, the United States, &c., and many of them had been absent from tropical climates for many years. Of the whites, 130 were attacked with fever on the Niger, and 40 died: of the native blacks, not one was attacked; but of the 25 others, 11 contracted fever, though none died. The power of acclimatisation is here apparent in the protection which the native blacks enjoyed over the others; and the protective power of race, again, appears in the comparative protection enjoyed by the foreign blacks over the whites. How far the different habits of these three classes may have led to these results we cannot say, but it has been seen above that Dr Daniell ascribes the great mortality of Europeans on the coast of Guinea to their not conforming to the habits of the natives.

While, therefore, it cannot be denied that sudden and extreme changes often destroy life before the system can adapt itself to the exigency, it seems evident that the protective power ascribed to acclimatisation must be sought chiefly in the adoption of the habits which experience has pointed out as affording the best protection against the influence of the active causes of disease.

Where the change is sudden, as in passing from a temperate to a tropical climate, or even from very fine to very inconstant weather, it is well known to be extremely trying to the health. But where it is gradual and not extreme in degree, as in passing from winter to summer, health is not much endangered, because the system has time to accommodate itself to its new circumstances. Different organs predominate in activity in different climates and seasons, and time is thus required to admit of the necessary changes taking place without disturbing the general balance of the circulation. In hot countries, for example, the skin and liver predominate greatly in activity in comparison with the kidneys and lungs; whereas, in a cold country, the case is completely reversed. If, therefore, a sudden transition be made from the one to the other without due preparation and attention to the requisite change of dress, the rapid change in the distribution of the blood from the surface to the internal organs, or from these to the surface, consequent on such change, is likely to be attended with danger; although the same change gradually effected would be unattended with any injurious results.

If, again, the change be from a healthy situation to one only a little less favourable, the consequences to the system will be also gradual and progressive. No immediate injury to health may be apparent, and the body may be said to adapt itself to the circumstances; but, in reality, health will be lowered and life shortened, in exact proportion to the amount of the injurious exposure and the state of the system at the time. Individuals of a peculiar constitution may live long, but the average of health and life will be positively diminished—a fact which shews that the apparent exception is more a fallacy than a reality, and that, *cæteris paribus, the highest health and greatest vigour will always be on the side of those who make the nearest approach to the fulfilment of the organic laws.*

It is therefore a glaring perversion of logic and reason to infer that we may safely rest satisfied with a limited portion of evil, on the plea that the constitution will adapt itself to the injurious agents around us. The argument ought to be turned in exactly the opposite direction. If the constitution possesses this power of adaptation to external circumstances, we are doubly bound to have it always surrounded with *beneficial* influences; seeing that, when the laws of health shall be fulfilled, the same tendency to adaptation will operate with equal force in permanently *ameliorating* the constitution. In every point of view, therefore, it is an object of much consequence to us to become acquainted with and adapt our conduct to all the laws of the animal economy.

It would be easy, were it consistent with the limits and purpose of the present volume, to shew, that although great advances have been made of late years both in physiological knowledge and in its applications to the promotion of human happiness, many of the usages current in society, and many of the practices resorted to in education, are still far from being in harmony with the laws of the human constitution; and that much good may be done by diffusing among the reflecting portion of mankind, and especially among the young, more accurate notions of the structure and uses of the various bodily organs, and of the conditions required for their healthy action. Illustrations in proof of this position, drawn from individual cases, may be cavilled at as incomplete, or regarded as accidental coincidences; but when the principle is exhibited in active operation on a large scale, minor qualifications fall into the shade, and leave the evidence absolutely unassailable. Many cases where the lesson cannot possibly be misunderstood, have already been adduced in the preceding pages; and I shall add here an example from the records of the army, both as being striking in its features, and as being one in which the public interest is deeply involved.

A few years ago, young growing lads were uniformly selected for the army, in preference to men of a mature age, on the supposition that, because their habits were not formed, they could more easily be converted into good soldiers than if taken a few years later. Many officers still entertain and act upon this opinion; and the period at which, by law, liability to military service commences in this country, remains fixed at eighteen years of age, although it has been raised to twenty by most of the Continental governments.

Examined physiologically, the practice of enlisting juvenile recruits seems peculiarly irrational. During growth, the conditions required for the healthy development of the body are, moderate and healthy exercise, plenty of nourishing food, abundance of sleep, and a cheerful state of mind. In making the transition from boyhood to maturity, the equilibrium of action between the different parts of the system is so much disturbed, that even under the most favourable circumstances an unusual susceptibility of disease prevails, which renders that period of life particularly dangerous. By consulting the statistical tables prepared by Mr Finlaison, and those of the population of Paris, already referred to (p. 218), it will be seen that, in all classes of society, the rate of mortality suddenly increases from the age of fourteen, when rapid growth may be said to commence, to that of twenty-three, when it is nearly completed. This truth will be made still more evident by the following extract from the Mortality Table of Berlin, constructed, on an average of 12 years, by Professor Casper.*

Ages.	Annual Number of Deaths.		Of all the Persons Living at these Ages, one Dies in	
	Male.	Female.	Male.	Female.
15	70	73	276	230
16	102	86	189	195
17	109	118	176	141
18	146	122	181	136
19	183	139	103	118
20	277	184	68	88
21	373	153	49	105
22	428	169	42	94
23	364	188	49	84

Here also, the rate of mortality begins to fall at twenty-three, and does not regain the same height till towards the fortieth year.

Viewing these results in connection with the laws of the animal economy, and bearing in mind that, even in peace, military service implies broken sleep, separation from friends, and occasional exposure to fatigue and privation, we must consider it almost self-evident, that an army composed of young lads at this hazardous period of life must be sickly and inefficient, and that a large portion of the expense and trouble bestowed in enlisting and training them must be entirely thrown away. That such is actually the fact, has unfortunately been too often proved by fatal experience. Dr Marshall, in the valuable work already quoted, adduces an irresistible mass of evidence to shew that, till growth is completed, it is impossible to form any correct estimate of the probable efficiency of a recruit; as numbers of apparently promising young men are cut off by affections of the chest, and other acute diseases, before attaining maturity, and before being exposed to any unusual privations or fatigue. So literally accurate is this statement, that Coche, a high French authority referred to by Dr Marshall, mentions distinctly, that even in time of peace, when no great hardships are to be encountered, volunteers, received into the army at the age of eighteen or twenty, pass two, three, or four years of their period of service in hospital, solely from inability to bear up against difficulties which scarcely affect those who are a few years older.

The French soldier joins the army at 20, and remains in service for seven years. The mortality in different years during this period is shewn by the official returns to be:—

			Per cent.
During the	first year	at the rate of	7½
...	second	...	6½
...	third	...	5½
...	fourth	...	4½
...	fifth	...	3
...	sixth	...	2
...	seventh	...	2*

These figures are remarkably corroborative of our doctrine; and if such be the results during *peace*, the practice in time of war, of enlisting very young men, cannot fail to be highly prejudicial to the recruits, and costly to the country. Dr Rush mentions among the facts observed by him during the American War of Independence, that "young men under twenty years of age were subject to the greatest number of camp-diseases;" while "men above thirty, and five-and-thirty years of age, were the hardiest soldiers in the army."* It appears, also, that, in the British army in Spain, sickness and inefficiency prevailed almost in proportion to the youth and the recent arrival of the soldiers. Sir James MacGrigor cites the 7th Regiment as an illustration, and adds, that between 9th August 1811 and 20th May 1812 it lost 246 men; of whom 169 were recruits landed in the preceding June, while only 77 were old soldiers. The original number of this detachment of recruits was 353, so that *more than one-half died within the first eleven months.* The total number of old soldiers, on the other hand, was 1143, and of them only 77 perished in the same time! So convinced, indeed, was Sir James of growing "lads being unequal to the harassing duties of the service," that in making calculations for measures in the field, he came to the conclusion that 300 men, who had served five years, would be more effective than 1000 newly arrived—not simply from their greater experience, but chiefly from the additional stamina proceeding from maturity.†

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* Die Wahrscheinliche Lebensdauer des Menschen. Berlin, 1835.

* Annales d'Hygiène Publique, April 1849, p. 242.

In a note subjoined to the preceding opinion of Sir James MacGrigor, Dr Marshall says: "Numerous examples might be quoted to shew that young lads are much less able to endure the fatigue of marching than men a little more advanced in life. During the winter of 1805, a French army, which was stationed on the coast in the neighbourhood of Boulogne, marched about 400 leagues to join the Grand Army before the battle of Austerlitz, which it effected *without leaving almost any sick in the hospitals on the route.* The men of this army had served two years, and *were not under twenty-two years of age.* The result of the march of this army may be compared with that of another under different circumstances. In the campaign of the summer of 1809, the troops stationed in the north of Germany marched to Vienna, but, by the time they arrived at the place of their destination, *all the hospitals on the road were filled with sick. More than one half of the men* composing this army *were under twenty years of age,* the usual levy of conscripts having been anticipated. After the battle of Leipsic, Napoleon made great exertions to recruit his army, and called upon the legislative senate to give him their assistance, to which they shewed some reluctance. 'Shame on you!' cried the emperor; . . . 'I demand a levy of 300,000 men, but *I must have grown men;* BOYS ONLY SERVE TO ENCUMBER THE HOSPITALS AND ROADSIDES.'"

In similar defiance of the laws of physiology, half-grown lads were at one time preferred for the East India service, on the false supposition that their unconsolidated constitutions would more easily adapt themselves to the climate than those of men already arrived at maturity—a proposition very nearly equivalent to saying, that because a person is already enfeebled, exposure to the causes of disease will *therefore* have less effect on him than if his strength were restored! Sir George Ballingall is entitled to the credit of having early and earnestly raised his voice against this doctrine, in his work on Fever and Dysentery, published on his return from India in 1819. His evidence is very striking; but so slow is the march of reason, that it was only in December 1829 that an order was issued from the Horse Guards that no recruits under *twenty* should be received for regiments serving in tropical climates; and so lately as the year 1826, nearly 15 per cent. of the king's troops in Bengal were under that age.

Dr Marshall also, in touching upon this question, supports his positions by reference to facts of a very conclusive kind, and to authors whose opinions ought to have great weight. Among other evidence, he quotes the register of a regiment employed in the Burmese territory in 1824–25; from which it appears that, in 1824, the ratio of mortality among the young men who went out with the corps was 38 per cent., or 1 in every 2⅓; while among the volunteers, who were considerably older, the mortality was 17 per cent., or only 1 in 6. In 1825 it was 30·5, or 1 in 3⅓, among the younger class, and *only* 6 *per cent.*, or 1 in 16, *among the elder.**

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* Medical Inquiries and Observations, by Benjamin Rush, M.D., vol. i., p. 299.

† Marshall on Enlisting, &c., p. 5.

Some other instances might be adduced in proof of the greatest mortality being always among the youngest men; and I might quote the case of a regiment mentioned by Dr Davies, in which, when it was sent out to Bombay in 1808, there was not a single private above 22 years of age, and in which, out of 550 men, nearly 300 required medical assistance within six weeks after he joined it: but it is unnecessary, as, although individual officers still prefer young men, the Government is at last awakened to their unfitness. A vague notion that growing lads do not bear fatigue, is indeed prevalent enough; but I venture to say, that if those by whom the age of enlistment was first determined had been well acquainted with the laws of physiology, and had possessed a clear perception of the conditions of healthy growth, the practice of receiving recruits at 17 or 18 years of age would never have been sanctioned, and the country would have been saved the pain and expense of sending thousands of young men to "encumber the hospitals and roadsides" of the Peninsula, or to perish under the exhausting influence of a tropical climate.

I have dwelt at some length on the practice here condemned, because, from the magnitude of its results, and the clearness with which they can be traced to the oversight of a natural law of the constitution, it affords an eminently instructive example of the evils arising from ignorance, and of the aid which might be derived from a general acquaintance with physiology, in preserving health and promoting the happiness of the race.

It was my intention to analyze, in the same way, various other practices in which public and private health is concerned; but I have already so far exceeded the limits originally proposed, that I must now conclude, leaving the reader to determine how far I am right in believing that information of the kind now communicated will be acceptable and useful to the public.

Let me however once more repeat, that I consider it a matter of *the most vital importance* to the welfare and prosperity of the nation that a knowledge of the laws which govern the animal economy should be taught in our schools. To every man health is the most precious of gifts, and every one should accordingly be placed in a position to guard and preserve the treasure. God has bestowed on each of us faculties to think and act for ourselves, and it is impossible that any one, however willing, or however well-informed, can, as our substitute, direct our actions in those minute details of every-day life, on which health has been proved to be so greatly dependent. If, then, we deny physiological instruction to the young, we make ourselves directly responsible for the continuance of these grievous and manifold evils which are the plain results of ignorance of the constitution of man, and its relations to surrounding objects.

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* Op. cit. p. 10.—In availing myself of Dr Marshall's labours, I may be allowed to express my high opinion of the benefit he has conferred by his statistical researches, not only on the service with which he was so long and honourably connected, but also on the public at large. There are many practical questions deeply concerning public health, which can be fully elucidated only by such masses of facts being grouped together as shall destroy all minor inequalities, and place the operation of principles prominently in view. But to effect this object with due regard to accuracy, requires an acquaintance with details, an acuteness of observation, and a power of successful generalization, which are rarely found in combination with adequate zeal and industry. It would be very useful if similar researches were instituted in regard to the occurrences in our public hospitals.

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